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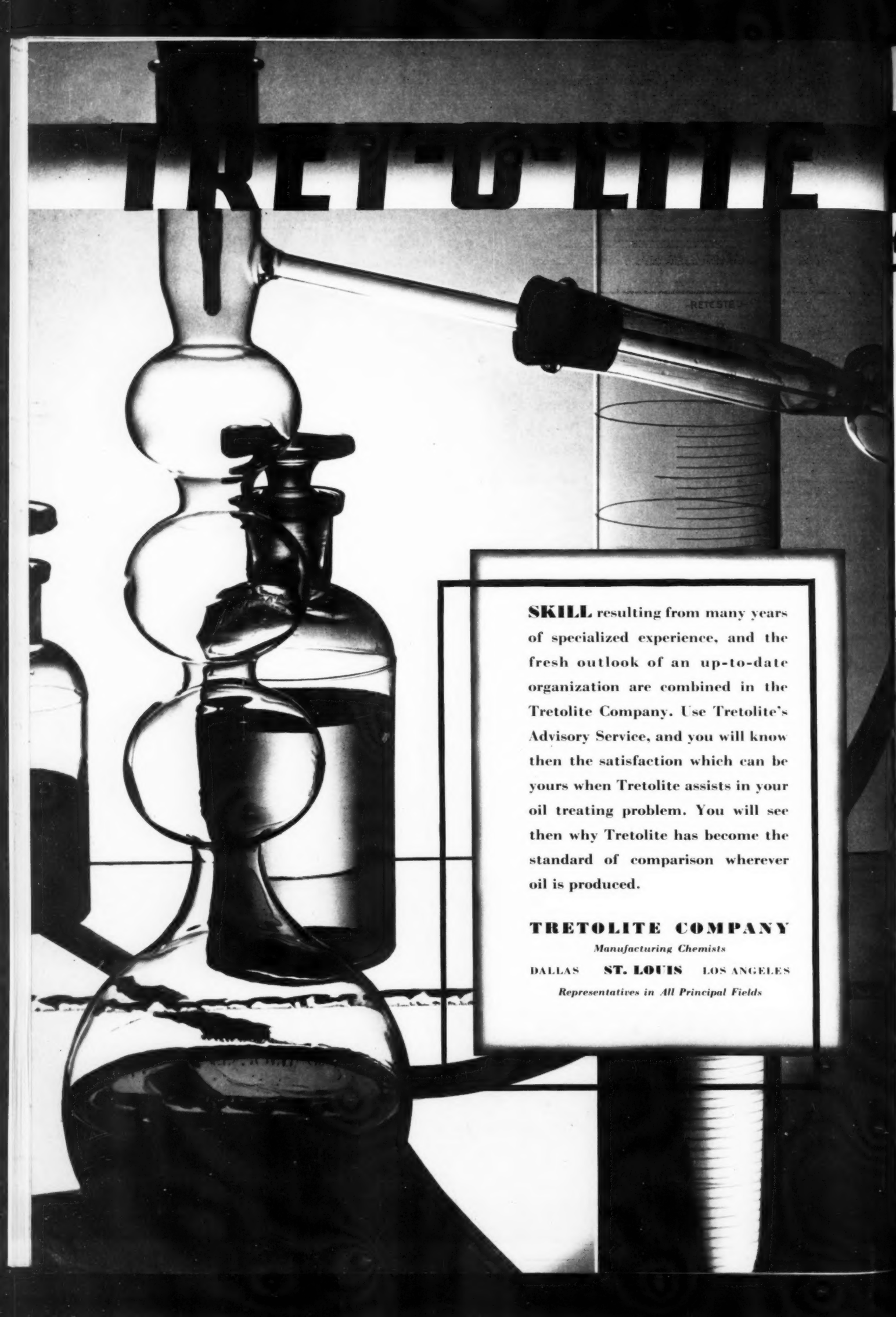

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NOVEMBER, 1940

THE Petroleum Engineer

VOL. XII—NO. 2

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The Course of Oil

By K. C. SCLATER

Continuous Well-Logging Technique Logging methods at rotary drilling wells are under constant development. Present advanced well-logging practice consists principally in determining by electrical means the type of rock penetrated, its location and its contents, whether oil, salt water, or gas. This is accomplished without reference to the drilling mud.

A new concept in continuous well-logging has recently appeared. The circulating fluid is the medium through which the well log is derived. The feasibility of logging by this method is based on the fact that relatively small quantities of oil, gas, or salt water can be detected in the drilling fluid.

Until the possibilities of utilizing the drilling mud in this manner were discovered it had been assumed that the amounts of gas, oil, or water present in the drilling fluid would be so small as not to be detectable with sufficient accuracy for practical purposes. Tests prove that this is not the case. Instruments are now available for detecting the small concentrations that may occur in the circulating-mud during the progress of drilling. The method has been in use now for more than a year and some 200 wells have been logged by this method, which shows promise of being a valuable contribution to well-logging technique.

This new method is based on the sound assumption that "it is for the fluid contents, rather than for the rock itself, that wells are drilled," hence, that a direct means of obtaining these data would be desirable.

In discussing this new well-logging technique in a paper presented before the American Petroleum Institute at Chicago this month, the author states that "Under modern rotary-drilling conditions the hydrostatic pressure of the drilling fluid exceeds that of the fluids in the permeable rocks drilled through, so there can be no appreciable inflow from these rocks while drilling. Actually the flow is in the opposite direction, filtrate from the water phase of the mud penetrating into the permeable formations at a rate depending upon the wall-building ability of the mud.

"Superficially it appeared, therefore, that the only ways to obtain an indication or sample of the fluid content of the rock would be to take a core and bring it to the surface, drill-stem test, or electrically survey and deduce the nature of the occluded fluids from the electrical resistance of the rocks containing them.

"It occurred to the writer that possibly the comparatively very small quantities of fluid contained in the pores of the cylindrical core of the material actually drilled and pulverized by the bit were not flushed ahead of the bit, but carried to the surface by the circulating fluid; and, further, that although—owing to the extreme dilution—the presence of these fluids could not be observed by the unaided senses, suitable instrumentation would enable detection. Both these suppositions have proved to be well founded."

The feasibility and practicability of this method of continuous well-logging may come as a surprise to many. The fact that the method has been used in some 200 wells is evidence of its practicability.

Development of this means of continuous well-logging marks another advance in field practice that promises to reduce still further the unpredictable hazards of oil exploration and exploitation.

Unnecessary, Unprofitable Drilling Unnecessary and unprofitable drilling is recognized as an evil besetting the industry and one difficult to eradicate. Lower operating and development costs, however, are becoming imperative—particularly for the individual producer. Though he "has little control over the price he receives for his product, he is in some measure able to control his costs.

"The producer can legally and in good faith bring about a substantial reduction in costs through one simple and very effective means, that is, to develop reserves with less capital expenditure. The real problem then is that of developing each reservoir with a sufficient number of wells to give an adequate supply of readily available oil at the lowest possible cost to the public, and at the same time develop these reservoirs with few enough wells to permit the producer to realize a reasonable profit."

In order to continue in business, operators today "must spread out their drilling pattern and develop their properties with fewer wells. Our present knowledge of reservoir performance permits the more intelligent use of reservoir energy. It is unsound, therefore, to drill more wells than are absolutely necessary."

At its convention in Dallas last month the Independent Petroleum Association of America emphasized that the oil producing business can be placed on a much firmer basis if certain constructive principles are followed and adhered to by all operators within the industry. Toward that end the following three-point program was recommended: "That the scientific approach to the problems of reservoir performance and control be continued, applying the most intelligent use of natural reservoir energy so as to realize the greatest ultimate recovery.

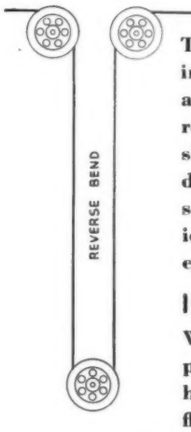
"That all allocation formulae be designed to give the greatest equity and that the principle of prevention of drainage across property lines which is not offset by counter drainage, be advocated and administered properly in all prorated areas.

"That all oil reservoirs be developed with the fewest possible wells in order that the largest quantity of proven reserves be made available at the lowest cost."

In the light of all the scientific and engineering facts concerning reservoir performance that have been discovered there seems "no reason to question the findings of the huge majority of experts when they contend that the density of wells has little to do with the ultimate recovery, provided the operations and withdrawals are controlled scientifically. A reasonable limit for the average present-day reservoir can without doubt be placed at one well to twenty acres and in many cases forty acres, or an even wider plan of development could certainly be justified."

These Wire Rope "Headaches" Should Be Avoided

Correct working conditions for wire rope are very essential if the rope is to deliver the full service of which it is actually capable. Some of the common causes of wire rope "headaches" are as follows:



REVERSE BENDS

This refers to that kind of bending in which a wire rope first passes around a sheave or drum in one direction and then around another sheave in a diametrically opposite direction. This is an exceedingly severe condition of wire rope service, and it should be avoided wherever possible.

IMPROPER FLEET ANGLE

Wire Rope trouble is sometimes experienced, particularly in mine hoisting, because of an excessive fleet angle. By fleet angle is meant the angle made by a line from the center of the sheave to the center of the drum, with a line from the center of the sheave to the outer side of the drum, as shown in the accompanying illustration.

This angle should not exceed, for best results, one and one-half degrees when smooth drums are used, and two degrees when grooved drums are used. Angles greater than these cause climbing on the drum as the rope approaches the end of the drum, with the resulting grinding and pinching tendencies, and is also likely to cause abrasion at the head sheave.

SHEAVES OUT OF LINE

It is essential for maximum economy, that all rollers, sheaves and drums be in line, otherwise at the point of misalignment there is excessive wear on both the sheaves and rope. Sheaves out of line have been known to have had one flange worn entirely off, which of course caused undue wear on the rope as well.

This advertisement is published for the purpose of helping all wire rope users obtain safe and efficient service from their wire rope. We publish a booklet "Practical Information on the Use and Care of Wire Rope," which covers many other conditions that deserve consideration. We would be glad to send a complimentary copy to anyone interested.

A. LESCHEN & SONS ROPE CO.

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« « HIGHLIGHTS IN OILDOM » »

San Francisco, Tulsa Chosen for A.P.I. Meetings

The board of directors, convening in Chicago in connection with the annual convention, chose San Francisco, California, for the 1941 annual meeting of the American Petroleum Institute, and Tulsa, Oklahoma, for the midyear meeting. The dates for the annual meeting are November 3 to 7, inclusive, and for the midyear meeting, May 19 to 23, inclusive.

●

Advance in Pennsylvania Crude Oil Prices

The Joseph Seep Agency of the South Penn Oil Company announced an advance of 15 cents per bbl. on three grades of Pennsylvania crude oil, effective November 12. The new prices are: Bradford-Allegany, $2.00 per bbl.; Southwest Pennsylvania, $1.65 per bbl., and Eureka, $1.59 per bbl.

The increase was the first this year. Previously there had been four cuts that dropped the price of Bradford-Allegany crude oil from $2.75 to $1.85. Operators said the advance was the result of increased demand from refineries, which in the last few weeks has exceeded production.

●

Bureau of Mines Compiles Figures on Petroleum

The production of crude petroleum in 1939 exceeded the 1938 record by 4 percent but failed to match the peak of 1937 by about 1 percent, according to a recent report of the U. S. Bureau of Mines. Had it not been for a 15-day shutdown in several states in August, 1939, a new annual record would have been established.

The total new supply of all oils in 1939 was 1,378,170,000 bbl., including crude-oil production of 1,264,962,000 bbl., natural-gasoline production of 51,650,000 bbl. (up 1 percent from 1938), benzol production of 2,498,000 bbl. (up 42 percent), and imports of 59,060,000 bbl. (up 9 percent).

Texas, the leading producing state, recorded a small gain in crude-oil output in 1939 but declines were registered in most of the other major states except Illinois, which experienced a sensational rise. Production in Illinois in 1939 was 94,912,000 bbl., a gain of almost 300 percent over 1938. Most of the large fields (East Texas, Oklahoma City, Kettleman Hills, etc.) declined in 1939 but the old Seminole district was an interesting exception.

Although widespread price breaks were imminent on several occasions in 1939, most postings remained virtually unchanged throughout the year; however, most reductions of October, 1938, were in force for the entire year, hence the average value per bbl. declined from $1.13 in 1938 to $1.02 in 1939. Pennsylvania Grade prices were again the most active ones and several increases raised the average about 20 cents per bbl. in 1939 over 1938.

Drilling declined and the number of oil wells brought in declined from 19,121 in 1938 to 17,485 in 1939. Despite the lower average value, the number of abandonments was much less than in 1938, with the result that the number of producing oil wells increased about 11,000 to a total of 380,390 on December 31, 1939. The trend of abandonments is influenced considerably by price changes in the Appalachian area, where there are many thousand stripper wells.

Another material reduction in crude-oil inventories was made in 1939, the principal difference from the 1938 performance being that more than half of the net reduction in 1939 was made in one month (August) when the 15-day shut-down program was in effect.

Crude runs to stills in 1939 rose to a new record of 1,237,840,000 bbl., or 6 percent above 1938. Of this total 33,490,000 bbl. (2.7 percent) was foreign crude.

Because of the comparative scarcity of heating oils early in 1940 and the top-heavy gasoline stocks, refiners have in the current year been keeping the gasoline yield about 2 percent below 1939, some of the decrease going to raise the yield of gas oil and distillate fuels. In 1939, however, the gasoline yield was 45.0 percent, the highest ever recorded. Most of the increase in the gasoline yield in 1939 (0.7 percent) was made at the expense of residual fuel oil.

The domestic demand for motor fuel established a new record of 555,509,000 bbl., or 6 percent above 1938. Exports of motor fuel instead of being stimulated by the war were depressed and the annual total dropped from 50,109,000 bbl. in 1938 to 44,638,000 bbl. in 1939. Notwithstanding the favorable domestic demand situation, stocks of gasoline were some 9,000,000 bbl. higher at the close of the year than at the beginning.

The domestic demand for gas oil and distillate fuel oil increased 18 percent over 1938, whereas residual fuel oil was up 10 percent. Stocks of both kinds of fuel oil showed a net decline for the year, presaging that more attention would be given to increasing the supplies of these fuels in 1940. The demand for most of the minor products increased in 1939, the gains in both the export and domestic demand for lubricating oil being particularly important.

●

Urge Separate Oil and Gas Commission for Texas

A resolution proposing creation of a new commission to take over the duties of the present Texas Railroad Commission in the regulation of oil and gas production has been approved by the executive committee of the West-Central Texas Oil and Gas Association, it is announced by President Joe A. Clarke of Albany.

The regional organization of independent oil operators, in a petition urging legislative action toward the cure of present proration and production ills in Texas, asked that the new regulatory body be separate from the present railroad commission and be headed by appointive officers.

Clarke recalled that Governor James S. Hogg, founder of the present railroad commission had warned, at the time the commission was established, of the harmful effects to the public interest of having the members of that body elected.

A bill providing for the new commission will be introduced early in the forthcoming session of the state legislature, Clarke revealed. The proposal likely will call for a three-man body to serve for terms of six years, with two years overlaps, he said.

Dependency of the National Defense Program on conservation of the oil and gas of Texas, and the necessity to "allay" demands for Federal control of the petroleum industry, were claimed by Clarke as the major reasons for the action of the West-Central Texas Oil and Gas Association in advocating a new conservation commission.

●

Pure Carbon Being Made From Petroleum

High-grade pure carbon has been added to the extensive list of products made from petroleum. Petroleum coke, the solid residue left by some types of refining processes, is a highly-efficient, low-ash fuel. In some states, however, where natural gas is plentiful and inexpensive, this coke has failed to find an adequate market. Now the first calcining plant has been completed to convert this coke into almost pure carbon. The plant will process about 384 tons of coke daily, recovering approximately 323 tons, or 85 percent, of high-grade carbon.

PENBERTHY PRODUCTS

Reflex

DROP FORGED STEEL LIQUID LEVEL GAGE

EMPTY SPACE SHOWS **WHITE** | LIQUID SHOWS **BLACK**

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USED TO OBSERVE COLOR AND DENSITY OF LIQUIDS UNDER HIGH PRESSURES, AND/OR TEMPERATURES

These gages are made of alloy temperature resisting steel and are of the highest quality throughout. Liquid chamber (both single and multiple section) is made from a solid block of steel to assure perfect alignment and rigidity. Frame has extra heavy beam at each end and glass chamber is accurately machined to contour of glass providing full metal backing for gaskets. Gage valves are drop forged steel with stainless trim.

These gages are available in any length and for various pressures and temperatures. All Penberthy gages conform with A. P. I.—A. S. M. E. requirements.

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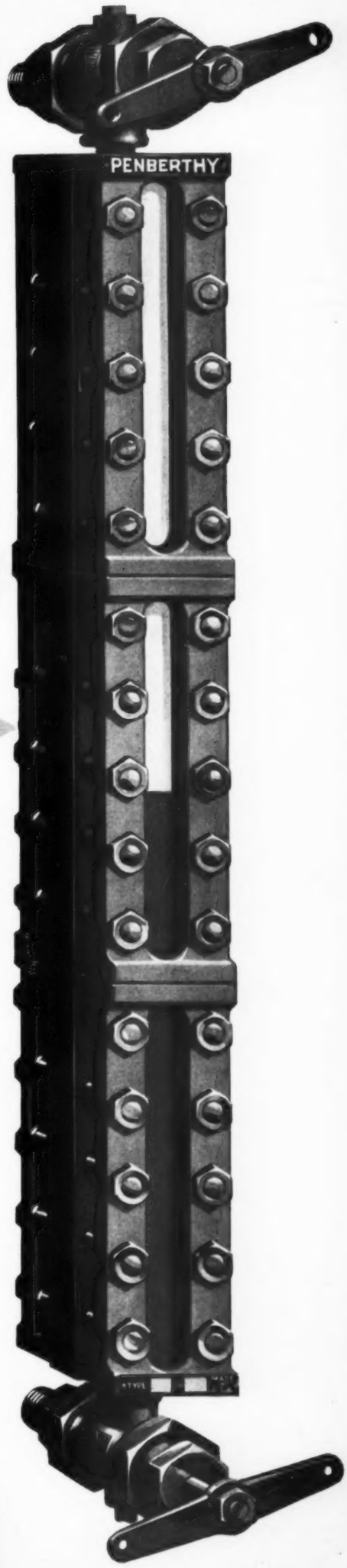

Activities in the Oil Fields

TAUBERT, McKee and Siemoniet have opened the second Ordovician pool for Pecos County, Texas, with their Virginia W. Crockett No. 1. The well flowed an estimated 75 to 125 bbl. of 43-gravity oil per hour from a depth of 5337 ft. Gas was produced with the oil at an estimated rate of 8,000,000 cu. ft. per day. Location of the well is 1½ miles east of Imperial and 10 miles northeast of the Apco field, Pecos' first Ordovician area.

●

A new oil field has been opened in southwest Hidalgo County, Texas, a mile east of the Samfordyce field, by Royal Oil and Gas Company's Yturra Town and Improvement Company No. A-1. The operators cored sand at 3489-3502 ft. and cemented casing on bottom at 3535 ft. The well, through perforations at 3497-3503 ft., produced 75 bbl. of oil per day through ⅛-in. choke. Tubing pressure was 925 lb. and closed-in casing pressure, 1350 lb.

●

The northeast edge of the Vacuum pool, Lea County, New Mexico, was defined when Great Western Producers, Inc., Honolulu State No. 2-E, was plugged and abandoned at a total depth of 4630 ft. in lime with 3100 ft. of sulphur water in the hole. A small volume of free oil was logged from 4556-70 ft., but the well ran into water at a depth of 4570 ft. and found broken increases to total depth. The dry hole was located 2310 ft. from the south line and 330 ft. from the west line of section 25-17s-35e.

●

A new producing area may be opened a half mile northwest of Roxbury, McPherson County, Kansas, by Henne No. 1, a wildcat operation of F. S. Williams and Joe Morine. Chat was penetrated at a depth of 2645 ft., and at 2651-58 ft. a good showing of oil was obtained and within a short time the hole filled 1800 ft. with oil. The operators estimated the well as good for 150 bbl. per day.

●

Lion Oil and Refining Company's and Donald Trumbo's Ogden No. 1, a wildcat in NEC of 17-14n-25w, between Huntsville and the Clarksville gas pool, in Madison County, Arkansas, and 30 miles southeast of Fayetteville, which produced 3,000,000 cu. ft. of gas from the Weddington sand at 230-47 ft., may result in the opening of a rich and shallow gas and oil area. Previously this zone, identified with the Mississippian-Caney and similar to the Bartlesville in Oklahoma, has produced only salt water.

●

Oil has been found in Barber County, Kansas, by the Barbara Oil Company's Angell No. 1, a wildcat in CNE SE of 10-33-14w, 4 miles west of production in the Medicine Lodge oil and gas field. The hole filled 150 ft. with 32-gravity oil from the Viola lime at 5049 ft. The operation failed to make a well, however, on its initial test and was being deepened.

●

Pure Oil Company's Spacek No. 1, a wildcat southwest of Ganado, Jackson County, Texas, has been successfully completed. The well was drilled to a total depth of 6600 ft., was plugged-back to 5475 ft. and several unsuccessful attempts made to obtain production. Eventually the hole was plugged-back to 5290 ft. at which depth the successful completion was made.

The well flowed 21 bbl. of 24.5-gravity pipe-line oil with no water.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.12-1.38	Rodessa	$1.05
Playa Del Rey	.65-1.08	Gulf Coast	.79-1.28
Coalinga	.60- .82	North Louisiana	.73-1.05
Wilmington	.64-1.14		
Montana	.80-1.10	Illinois	1.00-1.15
Wyoming	.35-1.30	Kentucky	1.05-1.20
Colorado	.90- .98	Indiana	1.00
New Mexico	.77-1.00		
Texas		Ohio	
North Central	.71-1.03	Lima	.90
Panhandle	.67- .96		
West Texas	.53- .95	Michigan	.81-1.18
Gulf Coast	.86-1.28		
Darst Creek	.96	Pennsylvania	
East Texas	1.10	Bradford	1.85
Talco	.65	Southwest	1.50
		Eureka	1.44
Kansas	.60-1.10	Buckeye	1.55
Oklahoma	.60-1.10	Corning	1.12
Arkansas	.73- .95	Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (October)	Week Ended Oct. 26, 1940	Week Ended Oct. 5, 1940	Week Ended Oct. 28, 1939
Oklahoma	403,500	[2]397,200	413,800	415,750
Kansas	178,700	[2]189,600	191,150	187,200
Nebraska	.....	[2] 2,600	1,000	.....
Panhandle Texas	.....	80,350	81,150	64,000
North Texas	.....	112,150	120,700	76,100
West Central Texas	.....	31,200	28,750	27,500
West Texas	.....	240,000	208,600	208,600
East Central Texas	.....	76,950	63,500	83,550
East Texas	.....	375,000	298,700	395,500
Southwest Texas	.....	225,700	199,150	193,100
Coastal Texas	.....	243,050	188,400	202,550
TOTAL TEXAS	1,305,200	1,384,400	1,188,950	1,250,900
North Louisiana	.....	67,000	64,750	65,700
Coastal Louisiana	.....	216,150	220,550	199,150
TOTAL LA.	274,200	283,150	285,300	264,850
Arkansas	70,700	68,950	71,450	65,900
Mississippi	9,000	[2] 15,450	19,200	800
Illinois	405,200	343,700	357,200	340,400
Indiana	9,300	[2] 19,100	19,800	103,100
Eastern (Not incl. Ill. and Ind.)	86,400	86,950	92,100	
Michigan	53,900	48,100	50,150	63,950
Wyoming	75,200	74,200	80,500	62,100
Montana	17,700	18,200	17,900	17,200
Colorado	3,900	3,350	3,250	3,900
New Mexico	104,500	101,450	97,650	115,750
TOTAL EAST OF CALIF.	2,997,400	3,036,400	2,889,400	2,891,800
California	583,200	603,900	599,400	606,700
TOTAL U. S.	3,580,600	3,640,300	3,448,800	3,498,500

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of October. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 A. M., October 23.

Great Pioneers

ALBERTA, CANADA, 1881

The Royal Canadian Northwest Mounted Police extended Canadian authority from Manitoba 800 miles west to Canadian Rockies, when they established Fort Macleod in 1874. Sitting Bull and his warring Sioux, after Custer Massacre, crossed into Alberta near this fort and remained in Canada until induced by Mounted Police to return and surrender in 1881. Alberta today, policed by this same daring force, is second largest oil-producing province in British Empire.

● What a variety of conditions Dowell Services will cope with this month—sunshine and balmy breezes in California—drenching Fall rains and near freezing temperatures in Illinois—blizzards in Alberta with the mercury hovering around zero. An oil operator at Pouce Coupe may want his well treated—it's the farthest north a well has ever been acidized. Dowell equipment would again be transported from Calgary 700 miles by rail—the well would be acidized with the same care and result-getting technique that makes Dowell Service preferred whether it be in Tampico, Mexico—McCamey, Texas—Salem, Illinois or Mt. Pleasant, Michigan. Thirty-one Dowell treating stations are strategically spotted throughout the United States, Canada and Mexico to provide prompt, efficient service regardless of weather conditions.

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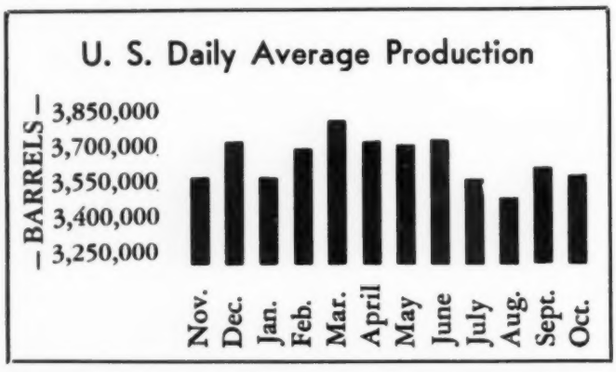
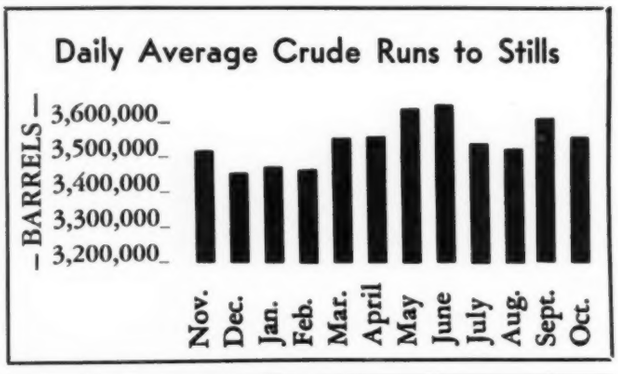
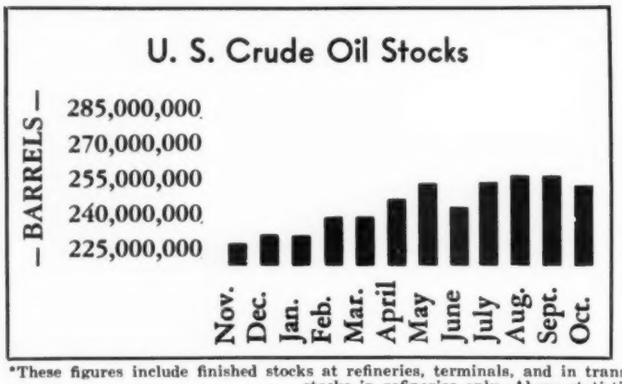
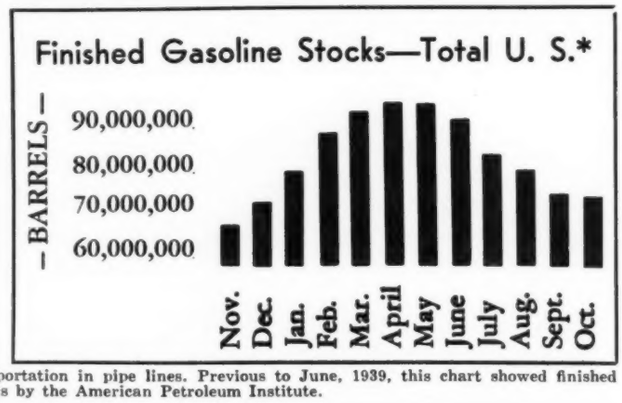
FOR OIL AND GAS WELL CHEMICAL SERVICE

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for October, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	27	26	5	14	3500-3700	2	40	Rotary
Duval County	28	13	5	15	1554-2900	2	22	Rotary
Ector County	44	43	17	45	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	45	44	15	60	1700-3900	2	40	Rotary
Refugio County	7	7	2	4	4900-5900	2	38	Rotary
Nueces County	16	12	3	6	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	22	22	12	45	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Fitts Pool	15	9	4	7	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	20	17	4	6	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	13	6	7	17	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	20	18	6	19	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	281	213	256	101	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	33	30	12	42	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	1	2	8	8300-8730	3 or 4	40	Rotary
Wilmington	17	17	13	9	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for October, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	October	September	October	September	October	September	October	September	October	September	
Arkansas	12	12	8	9	14	16	5	3	26	28	21,266,994
California	105	106	95	95	167	83	90	80	171	175	224,336,682
Colorado	....	2	....	2	....	....	2	2	26	30	1,402,599
Illinois	281	334	213	262	415	481	256	286	101	140	92,915,620
Indiana	56	57	40	41	....	....	15	21	77	81	1,426,000
Kansas	180	181	135	137	212	177	35	33	234	230	59,952,340
Kentucky	41	39	22	21	....	....	10	9	88	92	5,611,500
Louisiana	137	135	117	115	154	128	32	31	165	166	94,110,736
Michigan	102	100	56	53	126	95	34	37	148	147	23,185,203
Mississippi	20	22	10	11	....	....	11	9	38	36	102,918
Montana	30	28	26	24	....	....	10	10	50	54	5,901,058
New Mexico	41	39	31	28	39	32	24	26	122	118	37,453,117
New York	74*	76*	71*	75*	....	....	11	10	64	62	5,105,000
Ohio	130	138	85	88	....	....	50	47	173	168	3,157,500
Oklahoma	172	173	120	118	182	138	40	36	251	252	156,421,939
Pennsylvania	277*	275*	266*	265	....	....	....	....	....	....	17,342,500
Tennessee	....	....	....	....	....	....	....	....	....	....	....
Texas	753	729	556	552	1108	800	354	349	1101	1131	485,847,999
West Virginia	40	48	34	41	....	....	24	23	141	150	3,556,500
Wyoming	16	17	15	15	....	....	9	9	70	73	21,408,478
Total	2467	2511	1900	1952	2455	1950	1012	1021	3046	3133	1,260,504,683

*Includes water-intake and pressure wells.

Here's What

"SURFACE CONTROL", *means*

on the

NIXON *Surface Control* GAS-LIFT SYSTEM

1. **You can unload the well through the series of flow valves set in the tubing.**
2. **Change producing rate by changing the frequency of the lift periods.**
3. **Move from one flow level to another to follow the level of flow down the well.**
4. **Deplete a well with the original installation without changing or adding equipment.**
5. **Accurately control the amount of input gas used.**

Nixon Surface Control Gas-Lift System can be installed to flow wells from any depth in any volume, from off-bottom and in open hole; from the beginning of artificial flow through the stripper stage to depletion.

Hundreds of these Nixon Systems are now operating in fields throughout North and South America. In both deep and shallow wells they have set new low-cost standards of fluid-lifting.

If you want to reduce the cost of your fluid-lifting be sure you investigate the Nixon Surface Control Gas-Lift System. A Nixon Engineer can show you how to save money. Write your nearest Wilson Supply Company store or sales office and have an engineer visit you.

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EXCLUSIVE GULF COAST DISTRIBUTORS FOR:

Wilson-Snyder Pumps; American Cable Tru-Lay Preformed Wire Rope; Kewanee Boilers; Sievers Reamers; Drift Meter, Jr.; Gray Swivel; Nixon Surface Control Gas Lift; Nixon True-Taper Slip and Spider; Bowen Pack-Off and Releasing Drill Pipe Overshot; Douglas Weight Indicator; Coffey Robot Stack Draft.

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Fishing Tools and Service

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TEXAS: Gladewater; Barbers Hill; Bay City; Monahans; Alice; Victoria; Corpus Christi.
LOUISIANA: Rodessa; Lake Charles; New Iberia; Gretna; Shreveport.
ARKANSAS: Magnolia.
SALES OFFICES: Tulsa, Okla.; Dallas, Texas. LOS ANGELES: Phone W.L.A. 3-4040.
TRINIDAD B. W. I.: Neal Massey Engineering Corp.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 54.9 Percent **Central Division, 80.5 Percent** **Eastern Division, 89.6 Percent**

THE United States War Department recently awarded a contract to the Humble Oil and Refining Company for the construction of a toluene plant at Baytown, Texas. An expenditure of $11,857,000 is involved. Of this amount $10,760,000 represents the cost of erecting the toluene plant, and $1,097,000 will be spent in expanding the company's refining facilities, necessary to link the two plants.

The toluene plant will be erected on a 50-acre site adjoining the refinery. It will be built with government funds and owned by the government, but will be operated by Humble. Additions to the refinery will include a steam power plant, tankage, lines, housing, and similar equipment.

Construction contracts have been let to C. F. Braun and Company, E. B. Badger and Sons Company, and the M. W. Kellogg Company.

●

Douglas Oil and Refining Company is now installing in Los Angeles County, California, a 2-coil selective Dubbs cracking unit with crude distillation equipment. Universal Oil Products Company engineers designed the unit, including treating equipment and other auxiliaries, and Fluor Corporation of Los Angeles is building it. Provision is made in the design for future increases in capacity and for the addition of a catalytic polymerization unit.

The following are officers of Douglas Oil and Refining Company:

Chairman of the board, Donald W. Douglas; president, George W. Stratton; vice-president and director of operations and construction, William P. Andrews; secretary-treasurer, A. L. Bergere, and assistant secretary-treasurer, David C. Moore.

●

The Texas Company is completing construction of a new 120-ft. by 440-ft. machine shop and garage at its Port Arthur, Texas, refinery. A total of 52,800 sq. ft. of floor space is being provided. The space is divided among three bays, one 30 ft. wide, one 40 ft. wide, and one 50 ft. wide. The roof is of saw-tooth design and utilizes light-deflecting glass and corrugated asbestos, which provide protection against the weather and at the same time give an unusually well-ventilated and lighted interior.

●

The Consumers' Coöperative Refiners, Ltd., Regina, Saskatchewan, Canada, announces plans for the installation of a 1500-bbl. per day liquid-process type Perco copper-sweetening unit, to be in operation by January 1, or slightly before.

●

Distillate Engineering and Processes Company announces the sale of a license to The Texas Company under which that company will operate certain distillate or recycling plants. The first plant to be built by this company will be at Berwick, near Morgan City, Louisiana. Equipment is now being purchased for the project, which is scheduled for early completion.

This is the second recycling plant under way for Louisiana. The first one is in North Louisiana in the Cotton Valley field.

●

Mid-West Refineries, Inc., owner of a refinery at Alma, Michigan, has recently enlarged the scope of its activities by acquiring the two plants of the Imperial Refining Company at Grandville, Michigan.

The first step taken by B. J. Skinner, president of Mid-West, after the deal was completed, was to start installation of a 2-coil selective Dubbs cracking unit, with a rated capacity of 2000 bbl. per day of topped Michigan crude. The second step was to change the name of the newly acquired plants from Imperial to Mid-West.

The new cracking unit was designed by Universal and is being built by the Frick-Reid Supply Corporation.

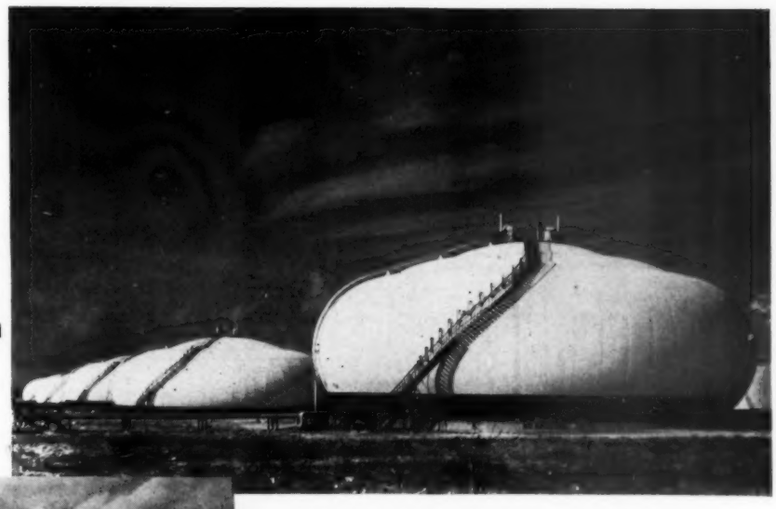
T. E. McFall and V. M. Skinner are vice-presidents of Mid-West, C. L. Fillmore is secretary and treasurer, and John Marshall is vice-president and general refinery superintendent.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended October 26, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

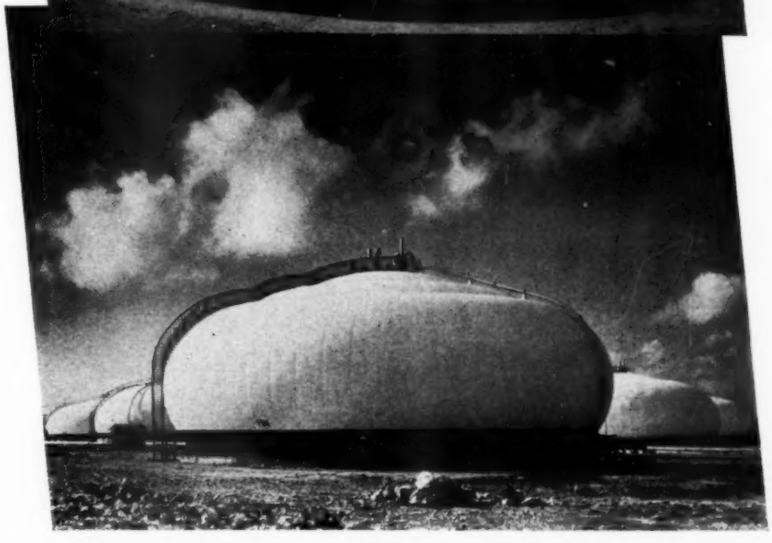
DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	598	93.0	18,958	30,966
Appalachian	91.0	122	85.9	3,235	1,069
Ind., Ill., Ky.	90.2	603	90.0	13,652	9,299
Okla., Kans., Mo.	76.9	253	78.3	6,186	3,928
Inland Texas	59.6	122	73.1	1,600	1,969
Texas Gulf	89.2	858	89.8	13,103	17,321
La. Gulf	97.6	110	68.8	2,634	3,257
No. La. and Ark.	51.5	48	92.3	481	883
Rocky Mt.	56.0	30	44.1	806	492
California	87.3	479	65.6	15,296	85,059
Reported	86.2	3,223	82.4	75,951	154,243
Estimated Unreported	.....	342	.....	4,940	3,125
*EST'D TOTAL U. S. OCT. 26, 1940	.....	3,565	.....	80,891	157,368
*EST'D TOTAL U. S. OCT. 19, 1940	.....	3,525	.....	81,656	156,982
U. S. B. of M. *OCT. 26,1939	.....	**3,580	.....	72,944	153,794

*Estimated U. S. Bureau of Mines' basis.
**October, 1939, daily average.

Refinery reduces evaporation loss from 1,860,000-bbls. of MOTOR FUEL *with*



HORTONSPHEROIDS



THE illustrations on this page show portions of one of the largest groups of Hortonspheroids ever installed at a single refinery for pressure storage of finished motor fuels. Twenty-two units are used for this service, with a combined capacity of 1,860,000 bbls. More important than the number of units, however, is the ability of every one of these Hortonspheroids to protect its contents against costly evaporation losses and resultant product deterioration.

No matter how large your motor fuel storage requirements may be, it will pay you to investigate the money-saving possibilities offered through the use of large-capacity Hortonspheroids (80,000 or 100,000 bbls.) designed to withstand pressures of from 2½ to 20 lbs. per sq. in. Hortonspheroids are also built in sizes up to 30,000 bbls. or more for pressures up to 30 lbs. per sq. in. for handling natural gasoline and other volatile products. Please address our nearest office for complete information about Horton pressure storage units.

CHICAGO BRIDGE & IRON COMPANY

Dallas	1471 Liberty Bank Bldg.	Chicago	2481 McCormick Bldg.	New York	3373-165 Broadway Bldg.
Houston	2919 Main Street	Detroit	1538 Lafayette Bldg.	Boston	1535 Consolidated Gas Bldg.
Tulsa	1634 Hunt Bldg.	Cleveland	2251 Rockefeller Bldg.	San Francisco	1064 Rialto Bldg.
Birmingham	1570 N. Fiftieth Street	Philadelphia	1635-1700 Walnut St.	Los Angeles	1446 Wm. Fox Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.

LICENSEES: Horton Steel Works, Limited, Fort Erie, Ontario, Canada; The Motherwell Bridge & Engineering Co., Ltd., Motherwell, Scotland; The Whessoe Foundry & Engineering Co., Ltd., London, England; Worms & Cie., Paris, France; Compagnia Tecnica Industrie Petroli S.A.I., Rome, Italy.

Major Pipe Line Activities

MAGNOLIA PIPE LINE COMPANY has awarded to the Williams Brothers Corporation the contract for laying an 8-in. welded pipe line from the Duggan-Slaughter pool of southeastern Duggan and southwestern Hockley counties, Texas, through the eastern part of the Wasson pool to the company's system that serves the Seminole field in central Gaines County. The line will be approximately 85 miles in length and will run slightly southwest from the Duggan-Slaughter pool to the Wasson pool, where Magnolia has large production, and thence south to the Seminole pool, in which area the company is one of the largest producers.

Another contract has been let for the construction of a gathering system in the Duggan-Slaughter pool. The new line will be the third serving the Duggan-Slaughter area. Magnolia is already serving the Seminole pool with 26 miles of 8-in. pipe that connects with the Atlantic Pipe Line Company's system from Hobbs, New Mexico, to Midland, Texas. As it touches the eastern part of the Wasson pool, the new Magnolia line will be the fifth serving that area. The Humble Pipe Line Company, the Shell Pipe Line Company, the Aloco Pipe Line Company, and the Basin Pipe Line Company are the other lines serving the field.

●

W. R. Davis and Company, Inc., are laying a 4-in. pipe line 15 miles in length from the Rincon field, northeastern Starr County, Texas, to railroad facilities at Rio Grande City. The line will extend from the Rincon field to the El Tanque field, about 11 miles southeast, thence to Rio Grande City, which is another 4 miles. Approximately 4000 bbl. of storage will be erected at Rio Grande City and the project will also involve more than 50 new homes and buildings in the Rincon field. The latter will accommodate families of workmen stationed in the field as well as additional workmen who will be sent into the area when W. R. Davis and Company, Inc., begin construction of a gas-distillate recycling plant.

●

Standard Oil Company of Louisiana has announced plans to lay a 35-mile line from the Olla field, La Salle Parish, Louisiana, to connect with its main system at the Rapides station. This will be the first pipe-line outlet for the Olla field, which is producing an average of 5000 bbl. of crude oil per day. At the present time, the oil is being moved by tank car to the Standard Oil Company's refinery at Baton Rouge.

●

Lone Star Gas Company has begun construction of an 8-in. gas line from the Page field, Schleicher County, Texas, to San Angelo, Tom Green County, a distance of 40 miles. The purpose of the line is to supply fuel gas to the plant of the West Texas Utilities Company, which heretofore has obtained its fuel from the Big Lake field in Reagan County, production in that field having been depleted.

The Lone Star Gas Company and its subsidiary, the Community Natural Gas Company, also will lay a branch line from San Angelo to the Army Air Training Field just outside the city.

Peoples Natural Gas Company, Pittsburgh, Pennsylvania, has leased to the New York State Natural Gas Corporation, an affiliate, a 90-mile pipe line extending from the Pew compressor station in Limestone Township, Clarion County, Pennsylvania, to Hebron Township, Potter County, Pennsylvania. The Public Utility Commission of Pennsylvania recently approved the leasing of the line.

●

The City Commission of McAllen, Texas, has approved a revised ordinance giving permission to the Ontario Oil Company, Ltd., of San Antonio for the construction of a pipe line through the city limits to industrial consumers as far west of the city as the Rado Refining Company's refinery, about two miles distant. The ordinance gives the Ontario company a right-of-way through the city only and expressly prevents it from selling gas to consumers within the city limits. E. A. McDaniel, attorney for the McAllen Utilities Board, said the city was proceeding with plans for construction of a municipal gas line to serve city consumers. Gas supply for both projects will be from the R. E. Harding Card No. 1, a large gas well about 300 ft. beyond the east city limits of McAllen.

●

The Magnolia Pipe Line Company has completed and placed in operation a trunk system from the Hull-Silk field, North Texas area, to the Ringgold station in Montague County, Texas. The project involved the laying of 42 miles of 8-in. line and 15 miles of 4- and 6-in. line, the latter gathering lines. In addition, a booster station has been constructed in the north end of the field. The company already was operating one trunk line from the Hull-Silk field and the new unit gives it a total capacity of 30,000 bbl. daily from the district and eliminates the need for pumping to Electra by way of the K.M.A. field.

●

Gas Corporation of Michigan is laying a 15-mile, 4-in. pipe line from the Lake George gas field to Clare, Michigan. The company serves Clare, Rosebush, and Mt. Pleasant with natural gas. Shamrock Pipe Line Company has the construction contract.

●

Williams Brothers Corporation has been awarded the contract to lay Pan American Pipe Line Company's new East Texas outlet, December 20 being specified as the date of completion.

Pan American, as announced in the October issue of *The Petroleum Engineer*, is laying 58 miles of 10-in. pipe line from Gregg County to Douglas and 137 miles of 12-in. from Douglas to Sinco. At the latter point the line will connect with an existing system of Pan American that extends to Texas City.

An 8-in. branch line 67 miles in length will be laid from the Cayuga field to Douglas to tie-in with the carrier from East Texas. In addition, 4 main-line pumping stations will be erected.

P 425.2
P 425.219.2

THE Petroleum Engineer

NOVEMBER, 1940

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Drilling Problems in Southern Oklahoma Field

Crooked hole, excessive bit wear, and high-pressure gas zone necessitate vigilant attention on drilling rigs

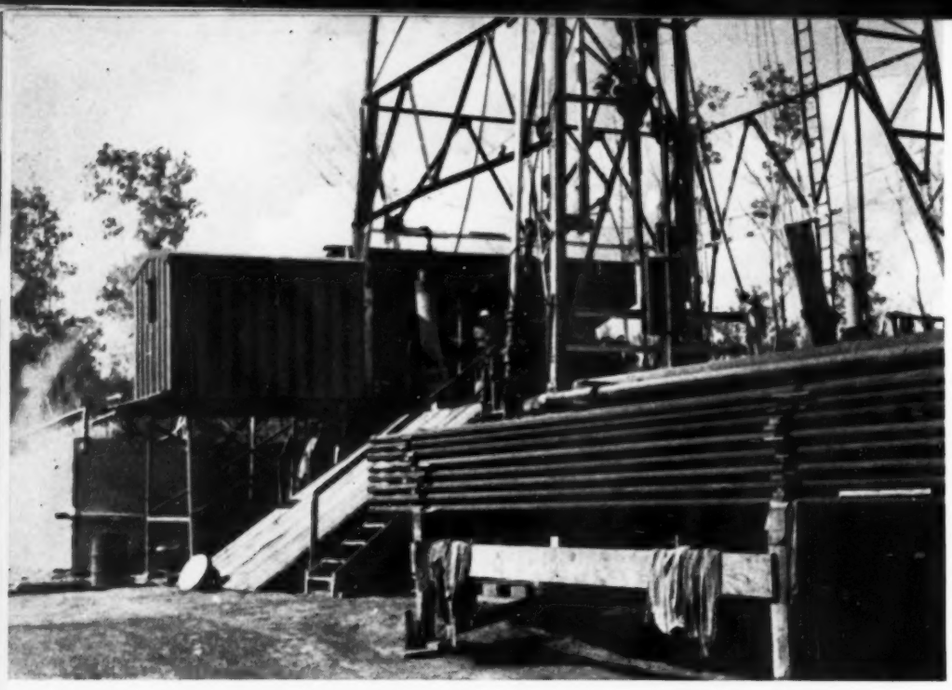
By H. LEE FLOOD
Associate Editor

IT WILL be recalled that during March and April, 1940, much interest was aroused by the discovery of oil in the area that will ultimately be flooded when the Red River Dam is completed and in operation. The dam, a Federal project on the Red River (the boundary between the states of Oklahoma and Texas), is situated a few miles north of Denison, Texas. The oil discovery was in what has since come to be known as the Cumberland field, named after the old townsite of Cumberland, between Ardmore and Durant, Oklahoma.

Since the completion of the discovery well in April, 1940, additional wells have been drilled in the Cumberland field in an orderly program of development. Whereas initial interest in the area involved the possibility that the field may some day be submerged beneath the lake formed behind the Red River Dam, the greatest amount of interest at the present time is in the drilling methods being employed to combat some of the problems that have been encountered.

The first point that attracts interest to the drilling program in the Cumberland area is the variety of drilling equipment to be found. Aside from this, the time required to complete the wells, the number of drilling bits, the difficulty of maintaining a vertical

Discovery well in Cumberland field, Oklahoma



Diesel rig on the bank of the Washita River will soon be converted to use natural gas as fuel

hole, the conditioning of mud to prevent blowouts, and the possibility of the drill pipe being stuck, are all important factors in drilling procedure that warrant consideration.

Drilling Equipment

At the present time there are eight rotary drilling rigs active in the Cumberland field. Perhaps in no other restricted area, have eight drilling rigs ever been concentrated that vary so widely in type. Differing principally, of course, in the type of power by which the rigs are driven, there is an excellent opportunity here to observe the relative performance of nearly every popular type of drive under substantially identical conditions.

Some of the equipment is soon to be revamped and changed so that gas may be used as fuel but at the present time, one well is being drilled by electric motor power, one by Diesel-engine power, one by engines using butane as fuel, one by steam power, and the other four rigs, formerly either powered by electric motors or by engines using butane as fuel, have been converted to engine drive, using natural gas as fuel.

The one remaining electric motor rig will be converted to gas-engine drive on the next well. The Diesel engines are to be changed-over to gas fuel instead of distillate, as soon as conversion heads are received from the factory. Eventually, all rigs will be utilizing natural gas as fuel. All equipment will then be powered by internal-combustion engines, of the vertical high-speed type; excepting the steam rig, of course, to which power is supplied by three 125-hp. boilers.

The assembly of such a miscellany of equipment resulted from moving-in whatever equipment was most readily available at the time it was needed. In other words, there was no conscious effort to specify these various types. The one factor governing choice of equipment on the first wells drilled was the lack of gas as fuel from any nearby fields.

Electric power was made available to the field by constructing a 4-mi. extension from a nearby high line that traverses this section of Oklahoma. Other than electric power, the contractors used butane or distillate until sufficient gas was being produced to serve as a dependable source of fuel.

Inasmuch as the Cumberland wells are completed at depths of approximately 5000 ft., medium-size drilling equipment is sufficiently heavy to drill to this depth satisfactorily. Equipment in seven of the rigs is comparable in size. The steam rig is the largest, having been moved from the Gulf Coast where it was used to drill to depths of 10,000 ft. and greater.

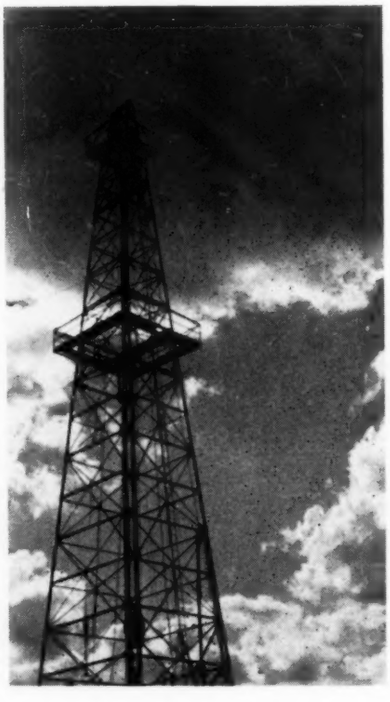
To complete the picture, it should be mentioned that one cable-tool rig, steam-driven, was moved into the area soon after the field was discovered. After spudding-in and drilling a few hundred feet with this outfit as an experiment, its use for well-drilling was discontinued. It is now being used to "tail-in" following a re-cement job in one of the wells on the east edge of the field.

Excessive Bit Wear

Aside from deviation from the vertical, excessive bit wear represents one of the most aggravated drilling problems of the area. Both of these problems, bit wear and crooked hole, and, in fact, most of the trouble encount-

Mud control is important factor in preventing blowout of gas-cut fluid

Rain clouds bring grief to these river-bottom wells



ered may be traced to the character of the formations encountered in the Cumberland area.

Production in the Cumberland wells is obtained from the Bromide sand at a depth of 5000 ft., but above this are a number of limestone formations that represent truly hard digging. The limestones are interspersed with shales containing very abrasive chert that has proved very difficult to penetrate.

Other than in the discovery well, in which the time required to complete the well and the number of bits used were excessive and not representative, it has required 55 to 75 days to complete these 5000-ft. wells, using not less than 50 or 60 bits. One well now nearly completed drilling has required 89 bits to drill to a depth of nearly 5000 ft.

The footage obtained from rock bits has varied from 1 or 2 ft. on up. Representatives of bit manufacturers have been studying the problem and have given excellent service to the field. Bit performance is being correlated with the various formations in the wells thus far drilled and a more exacting bit schedule is thus being developed. One or two entirely new bit designs have been tried in the field and have shown promise of being the answer to the specific problems encountered in this area.

Weight indicators are watched religiously to prevent crooked hole

Automatic weight indicator used on steam rig. Preparing to move to another location

Combating Crooked Hole

In the Cumberland wells, deviation from vertical is required to be not greater than 2 deg. in setting the surface string and not more than 5 deg. in drilling the well.

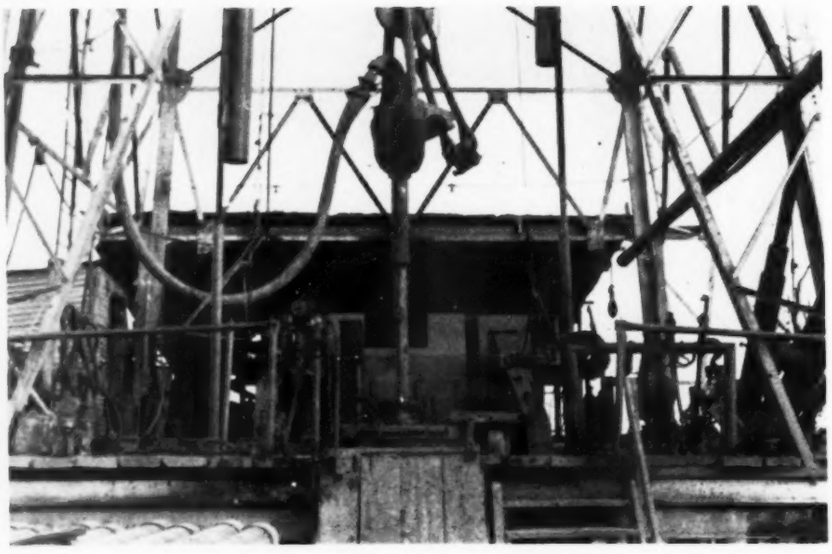
It is only by exercising constant attention that the holes are prevented from exceeding these limits. For this reason, weight indicators are used even more religiously than in normal drilling operations. The weight on the bit seldom is permitted to exceed 1 point and the practice by most of the drillers in the field is to "pay out" the drilling line at as nearly a constant rate as is manually possible, rather than letting the bit "drill off".

The importance of weight control at Cumberland is indicated by the fact that, on one of the rigs, an automatic weight controller is being used. Use of automatic devices of this type to control weight on the bit has never become widespread, possibly because in normal drilling the advantage of continuous advance of the bit is not so clearcut as at Cumberland.

The automatic weight control equipment consists of a power unit driving a self-locking worm gear through a variable speed, reversible hydraulic transmission. A sprocket on the worm gear shaft connects to the line shaft on the drawworks. The mechanism in the control box, either under manual or automatic control, varies the speed or direction of the hydraulic transmission, thus controlling the rate at which the drill pipe is raised or lowered. The device automatically maintains any desired weight on the bit as set by the driller, and feeds the bit accordingly. It accurately responds to either a small decrease (or increase) in the weight, and pays out or retrieves the wire line supporting the drill pipe in the exact amount necessary to maintain the weight specified. Automatic operation may be discontinued and manual control returned to at any time.

In the Cumberland field, this automatic weight control device has proved eminently satisfactory. Its use has min-

Cable-tool rig, found not suitable for hard digging at Cumberland, is being used to tail-in following a re-cement job



The derrick floor of one of the Cumberland rigs

imized the tendency of the drill bit to deviate from vertical drilling because of the close control of weight on the bit. More important, its use has made it possible to go back in the hole with a new bit and lose as little time as possible in drilling through the tapered hole drilled by the previous bit. This is important at Cumberland because the severe wear causes even the best bit to lose gauge rapidly.

No better display of the various schools of thought on the amount of drill collar to be used can be found than in the Cumberland field. The usual practice is to use three 30-ft. drill collars but one contractor plans to use six 30-ft. collars on the next well drilled. Although the importance of drill collars is recognized fully as a factor in maintaining vertical hole, less attention is given to this than to weight control at the surface.

Likewise, there is some variation in practice concerning speed of the table. One contractor is drilling at 180 r.p.m. but this is the maximum speed used in the field. The usual table speed is 100 to 125 r.p.m.

Key-Seating Causes Stuck Pipe

Although only nine wells have been completed in the Cumberland field, there have been two or three fishing jobs, causing the contractors to be on the alert to guard against this contingency.

Because of the aggravated crooked-hole condition, considerable thought has been given to the possibility that key-seating is occurring and may be contributing to the ease with which the drill pipe becomes stuck.

One of the best discussions of key-seating as a cause of stuck drill pipe was presented in a paper last spring.[1] When a hole becomes crooked and the dog legs become pronounced, the tendency of the drill pipe (in tension) to straighten itself causes the pipe to abrade or wear into the wall of the hole, thus creating a notch or slot only slightly larger than the drill pipe itself. When the drill bit is pulled up into this slot or key seat, it binds and becomes stuck.

If it becomes apparent that a key seat is forming, it is good practice to keep it reamed to the diameter of the drilled hole. The usual procedure is to run a reamer in the drill stem located at a point just above the key seat when the bit is on bottom.[1]

It has been unnecessary to resort to reaming in the wells at Cumberland but it is probable that this practice will be adopted if the crooked hole tendency cannot be minimized.

Mud Control

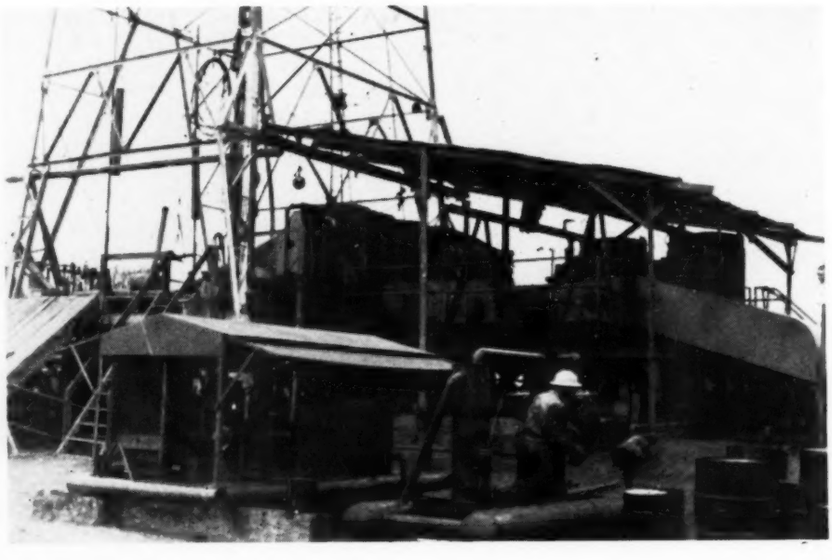
The presence of a high-pressure gas sand at a depth of about 2800 ft. in the wells at Cumberland caused one or two serious near-blowouts in the earlier wells drilled and has occasioned a very close control of mud characteristics, particularly after the wells reach the gas sand.

Inasmuch as no mud at all is obtained from the hard, limey formations in these wells, it is necessary to import all materials entering into make-up of the circulating fluid.

The weight of the mud is permitted to vary from 10 to 11.5 lb. per gal. On only one occasion has it been necessary to increase the weight to 13 lb. to withstand the tendency to blowout. Viscosity of the mud is from 40 to 47 Marsh sec., and the pH usually is about 8—being high because of the lime content of the formations. Other tests of the mud, although not critical, are made periodically. For example, the chloride content is low, averaging 0.20 percent; the filtrate is about 20 cc.; the cake thickness is usually 6/32-in. and the sand content about 2.5 percent.

[1] "Causes, Preventions, and Recovery of Stuck Drill Pipe" by J. E. Warren. Paper presented at the Spring Meeting, Southwestern District, A.P.I. Division of Production, Houston, Texas, March 28-29, 1940.

Gas scrubber in foreground will come into use when natural gas is substituted for butane as fuel



Heating Natural Gas to Prevent Hydrate Formation

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Application of heat transfer principles results in accurate design of heaters

By J. R. COWLES
Engineer, Oklahoma Natural Gas Company

Introduction

THE heating of natural gas to prevent its freezing has been practiced for years, yet there is very little written directly on the subject that will aid a person confronted with the problem of designing a heater. It is the writer's hope that this article will encourage others to present such information as they may have, in order to place this increasingly important subject on a more exact basis.

Theoretical Considerations

General. A reduction of gas pressure by means of a regulator, or similar device, causes three changes in physical properties of the gas. These three properties are:

1. Temperature.
2. Ability to hold water in the vapor state.
3. Temperature of freezing.

The ability to hold water in the vapor state and the freezing temperature of the gas are favorably affected by a pressure reduction. Unfortunately, these changes are more than offset by the change in temperature. Thus, the temperature change is enough that water will be condensed from a reasonably well-saturated gas and, if the gas is close to its freezing temperature originally, the temperature drop will cause the gas to fall below its freezing temperature. Freezing is then quite probable, the temperature being favorable and water condensate being present.

A quantitative study of these factors can be made by the use of Figs. 1 and 2, and a set of curves showing the maximum water content of natural gas at different pressures[7].

Freezing of gas. The most generally used hydrate formation temperature data are probably those of Hammerschmidt[6], which are plotted in Fig. 1. The actual data go to a pressure of about 900 lb. per sq. in., but the extrapolated curve has been confirmed in the field by several workers.

Temperature drop accompanying pressure drop. To date, the writer has found no published data on the temperature drop that accompanies pressure drop when natural gas is passed through a pressure-reducing device. Permission has been obtained, therefore, to reproduce the chart entitled "Temperature Effects of Throttling Gas Produced from Distillate Wells." (See Fig. 2.) Though developed for distillate well gas, the writer has found these curves applicable to gas from each of two wells in which the rock pressure gauged approximately 2000 lb. per sq. in., but neither of which were making distillate in appreciable quantity. Furthermore, these data are in good agreement with published data on methane[5].

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Specific heats and enthalpy. Enthalpy is the most desirable property to consider in heater calculations as the pressure drop through a heater is sometimes great enough to cause an appreciable drop in gas temperature were it not for the fact that heat is being added to the gas. Using an enthalpy basis, this factor causes no difficulty, but when specific heat calculations are used, there is a definite heat input to the gas that is not reflected in the temperature rise occurring in the heater. Consequently, specific heat calculations are complicated considerably.

A search of the literature reveals two convenient sources of enthalpy data, both of which have advantages. The simplest is the enthalpy data on methane[5]. These data, converted to convenient units, are presented as Fig. 3. Obviously, methane data are not always acceptable as a basis for design. For cases in which methane data are not suitable, the method outlined by Dr. G. G. Brown[2] affords a more rigorous determination, even when the designer does not have a complete fractional distillation analysis of the gas in question, a test that is not always available or justified.

The specific heats of methane are presented in Fig. 4. The specific heat of a gas can be calculated from enthalpy data when it is needed and when the gas is one for which methane data are not appropriate.

Heat required by gas to prevent freezing. Using Figs. 1, 2, and 3*, it is possible to generalize on how much heat must be put into the gas stream under ordinary conditions, by assuming (1) that the gas is saturated with water, and is received at a temperature just above its freezing temperature, and (2) that when the gas is released into the pipe line, its temperature has remained just above freezing. Fig. 5 is the result of a set of calculations based on this reasoning†. The form of the chart is rather unorthodox and its use can bear a word of explanation. The bottom scale (abscissa) has no fixed origin. Each division represents 100 B.t.u., and the value to be read is the distance between the two vertical lines drawn from the intersection of the curve with horizontal lines through the initial and final pressures (ordinates). Fig. 5 may, at first glance, appear to be a very rough estimate; unless the gas is received dangerously near freezing conditions, however, the heat requirements indicated

*Methane enthalpy data could be used more conveniently than specific heats in making these calculations, but the use of the temperature drop based on an actual gas should be more satisfactory than assuming that natural gas behaves the same as methane, when it is unnecessary to rely upon such an assumption.

†Fig. 3 was not available when Fig. 5 was made and a much smaller plot of specific heat data had to be used. It is to be expected, therefore, that recalculation of Fig. 5 would yield a slightly different curve, though the accuracy of the curve would not be greatly altered.

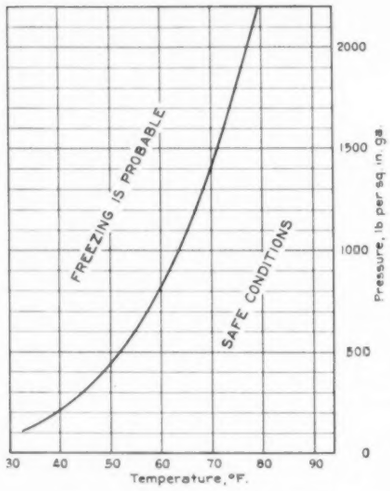


Fig. 1. Hydrate formation temperatures

by this graph should even afford a small factor of safety.

Pressure Drop in Small Pipes and in Heaters

General. If the use of a heater is being given consideration, this in itself is evidence that the gas is being subjected to conditions in which freezing is probable. Unless the gas as received is at a temperature considerably above its freezing temperature, careful consideration must be given to pressure drop as a cause of freezing.

Inasmuch as a heater is usually set near a regulator, or similar device, it may be expected that the pipe in and around a heater will be relatively small in diameter and that the pressure drop through these small lines should be considerable. Such conditions, together with the fact that the supercompressibility of the gas can be appreciable at the pressures encountered in some heaters, preclude the use of Weymouth's formula *per se*. Accordingly, the following general formula for pressure drop is given. It is based on chemical engineering procedure[8], and is given in differential form, because supercompressibility at high pressures cannot be expressed as a simple function of pressure.

General pressure drop formula:

$$\frac{dp}{dn} = 9\frac{fQ^2Z}{PD^5}$$

where $f = \phi\ (Re)$

and $Re = \frac{29Q}{D\mu} \times 10^5$

(0.6 sp. gr. gas assumed)

$\frac{dp}{dn}$ = pressure drop, lb. per sq. in. per ft.

f = Fanning friction factor, no dimensions.

Q = flow in M. cu. ft. per hr.

Z = supercompressibility factor, no dimensions.

P = absolute line pressure, lb. per sq. in.

D = I.D. of pipe, in.

Re = Reynold's Number (a measure of turbulence), no dimensions.

μ = viscosity of gas in micropoises.

For the relationship between Reynold's Number and the Fanning friction factor, f, the reader is referred to a standard text on chemical engineering or hydraulics, though the equation $f = \frac{0.0464}{Re^{0.18}}$ probably yields results well within the accuracy that may be expected from such calculations.

Determining the exact value of the supercompressibility factor that should be used depends largely upon what information about the gas is available. In some cases, direct supercompressibility measurements may be available. If a fractional distillation analysis of the gas has been made, the method outlined by Brown[1] is perhaps the most satisfactory method. In the absence of either direct measurements or a complete analysis, the writer suggests the use of the supercompressibility of methane[3]. Values based on methane will probably not be large enough numerically, but they will afford a sizable correction in the proper direction. Furthermore, they may be used when involved calculations are not warranted.

Viscosities of methane and of a lean natural gas have been determined by Sage and Lacey[10], and their curves are presented as Fig. 6. (The writer wishes to thank the A.I.M.E. for permission to reproduce these curves.)

The upper graph of Fig 6, showing the viscosity of a lean natural gas is based on a gas having the following composition:

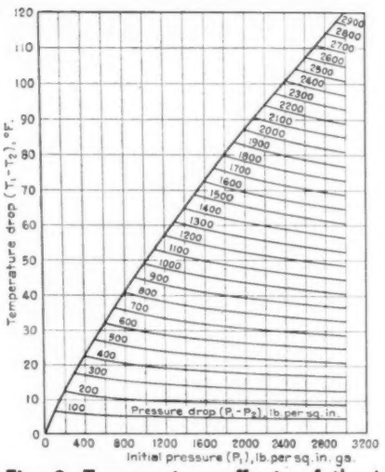


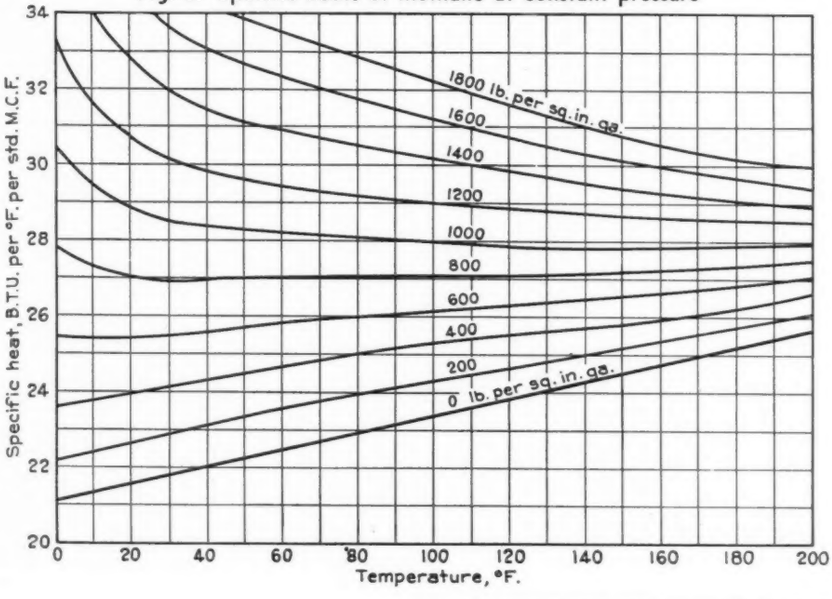
Fig. 2. Temperature effects of throttling gas produced from distillate wells
(Courtesy Black, Sivalls and Bryson)

	Volume, percent
Methane	83.19
Ethane	8.48
Propane	4.37
*Iso*butane	0.76
n-Butane	1.68
*Iso*pentane	0.57
n-Pentane	0.32
Residues (as n-hexane)	0.63
Total	100.00

Sp. gr. (air 1.0) = 0.708

Pressure drop in heaters. By the same method outlined above, it is possible to estimate the pressure drop inside a heater of any given dimensions if allowances are made for the effect of bends by adding the equivalent length of straight pipe to the total length of the heater tubes. The align-

Fig. 3. Specific heats of methane at constant pressure



ment chart[4] titled "Resistance of Valves and Fittings to Flow of Fluids", is a very convenient source of this information, or it may be found in tabular form in most texts on hydraulics.

Location of pressure-reducing device. In the foregoing discussion of heat requirements and pressure drops, nothing was said about whether pressure drop should take place before or after heating. Although the writer does not possess wellhead temperature and pressure data for a great number of wells, it appears that quite often the wellhead temperature is not enough greater than the hydrate formation temperature to permit much pressure reduction before heating the gas. At the same time, however, it is desirable to have the gas as cold as possible when it enters the heater in order to enjoy the advantage of as much temperature difference between the water in the heater and the gas as is possible. It appears, therefore, that each case should be considered on its own merits, using Figs. 1 and 2, and making the calculations outlined above whenever necessary.

Performance Tests on an Existing Heater

Heater construction**. The heater tested is, in effect, a water heater connected to a separate heat exchanger. The water heater is a 10-hp. vertical boiler, and the heat exchanger consists of five 75-ft. lengths of 1¼-in. extra heavy pipe connected in parallel. Each tube in the exchanger has two 180-deg. bends. The flow of water in the outer shell is substantially countercurrent.

The data obtained on this heater were intended to afford a study of minor operating troubles and to determine maximum capacity. Conditions listed do not necessarily represent good operation. Accompanying are tables showing a summary of the field data, and the various values calculated from these data. (Tables 1 and 2.)

Sample calculations on heater. Calculations are necessarily based on enthalpy, because the extreme test conditions employed resulted in hydrate formation ahead of the heater. These hydrates entered the heater and melted, resulting in an abnormally small temperature rise through the heater. Consequently, calculations based on specific heat and temperature rise are worthless. In making enthalpy calculations, the enthalpy at the wellhead was only calculated once. All gas in the producing formation should have the same enthalpy, and heat transfer through the casing to the outcoming gas should be negligible in the high rates of flow encountered. Heat transfer coefficients are based on arithmetic mean temperature differences because of the complicated contact between the two heat streams (gas and water).

Consider Run No. 1: Wellhead enthalpy, from Fig. 4, is 1.29 B.t.u. per cu. ft. (80°F., 1740 lb. ga.). Enthalpy at heater outlet is 2.12 B.t.u. per cu. ft. (63.5°F., 750 lb. ga.). Net change is 2.12 — 1.29 = 0.83 B.t.u. per cu. ft. Inasmuch as 1202 M. cu. ft. per hr. is the volume to be heated, the amount of heat picked-up by the gas is 0.83 × 1,202,000 = 1,000,000 B.t.u. per hr. Average gas temperature is $\frac{52 + 63.5}{2} = 57.7$°F., and average water temperature is $\frac{141 + 82}{2} =$ 111.5°F., an average gas-to-water temperature of 53.8°F.

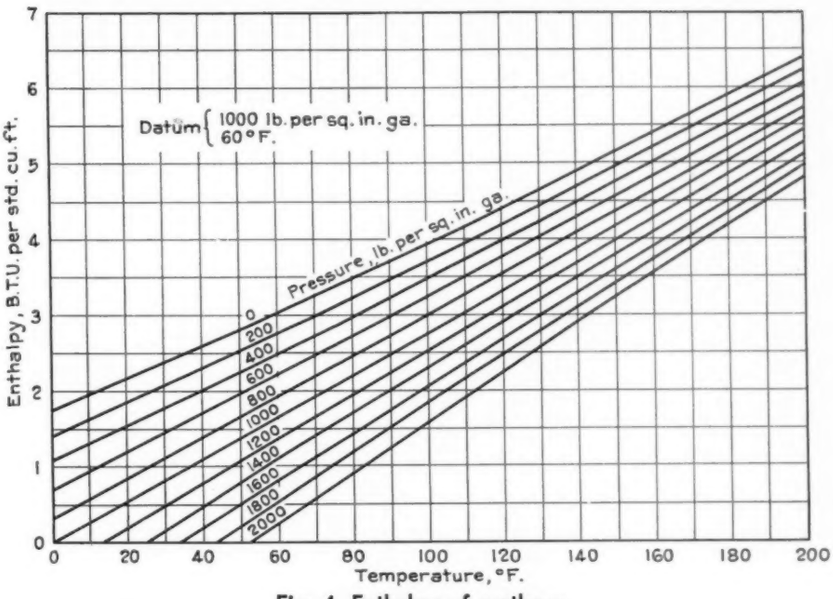


Fig. 4. Enthalpy of methane

TABLE 1
Field Data on Heater

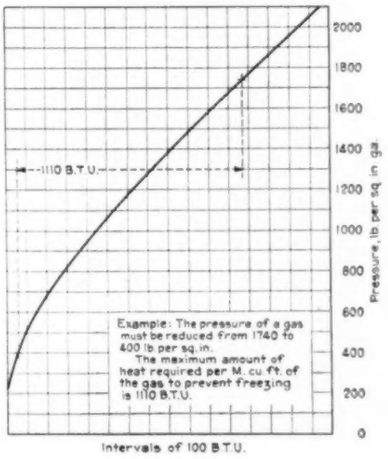
Run No.	Pressure at outlet of heater, lb. per sq. in. ga.	Standard M. cu. ft. gas heated per hr.	Temperature of gas		Temperature of water	
			Inlet, °F.	Outlet, °F.	Inlet, °F.	Outlet, °F.
1	750	1202	52	63.5	141	...
2	750	1158	52	63	141	82
3	1300	933	65	92	146	105
4	1630	715	75	113	155	118
5	1770	481	77	134	161	128

Note: Wellhead temperature at 1740 lb. per sq. in. gauge pressure was 80° F.

TABLE 2
Calculations—Heater Test

Run No.	Standard M. cu. ft. of gas heated per hr.	Heat picked up by gas—thousands of B.t.u. per hr.	U-B.t.u. per hr. per sq. ft. per °F. based on mean pipe diameter and arithmetic avg. temperature difference	Re in tubes ×10⁻⁵
1	1202	1000	129	4.01
2	1158	939	121	3.86
3	933	850	126	2.71
4	715	829	135	1.97
5	481	814	146	1.29

Fig. 5. Maximum heat required by wet gas expanded through regulators, chokes, etc.



**This heater was described in "Hot-water Heater for Preventing Freeze-offs of Large-Volume Gas Well" by Roy W. Parker, *The Petroleum Engineer*, August, 1939.

Having the above figures, it is now possible to calculate the rate of heat transfer within the heater. This rate, commonly designated by U, is the number of B.t.u. that pass through a sq. ft. of heating surface in an hour when there is a 1° temperature difference between the gas and the water. Using a mean heating area of 145 sq. ft., U for Run Number 1 is $\frac{1{,}000{,}000}{145 \times 53.8} = 128$ B.t.u. per hr. per sq. ft. per °F.

As enthalpy was used to make the above calculations, there is no need to calculate pressure drop within the heater. An average pressure and a Reynold's Number will be needed, however, for a later correlation; hence, the following sample calculation is given for Run No. 1:

Including equivalent lengths for bends, there are, in effect, 105 ft. of 1.278-in. I. D. pipe through which $\frac{1202}{5} = 240.4$ M. cu. ft. of gas per hour are flowing.

Using $f = \frac{0.0464}{Re^{0.18}}$

where $Re = \frac{29Q}{D\mu} \times 10^5$:

$$f = \frac{0.0464}{(4.03 \times 10^6)\ 0.18} = 0.00298$$

$$(Re = \frac{29 \times 240 \times 10^5}{1.278 \times 135} = 4.03 \times 10^6)$$

Using the equation $\frac{dp}{dn} = \frac{9fQ^2Z}{PD^5}$

$$\frac{dp}{dn} = \frac{9 \times 2.98 \times 10^{-3} \times 240.4^2 \times 0.9}{765 \times 1.278^5}$$

$= 0.536$ lb. per sq. in. per ft. The 0.9 appearing in the equation is the supercompressibility of methane at the average heater pressure and temperature. $\triangle p$, therefore, is $0.516 \times 105 = 56.2$ lb. per sq. in., giving an average pressure in the heater of $750 + \frac{56.2}{2} = 778.1$ or, for all practical purposes, 780 lb. per sq. in.

As the above pressure drop calculations are dependent on Z and μ, which are in turn dependent on the average pressure, it may be necessary to make several approximations in some cases. In the above instance, however, no second approximation is necessary.

General Correlation of Heat Transfer Rates

General. Knowing the theoretical amount of heat required in any given case, the amount of gas that must be burned to supply sufficient heat, and the size of the equipment to burn it in can be estimated from a knowledge of boilers and other heaters. The main difficulty is the size and number of tubes to use. Accordingly, the preceding data, together with additional data kindly supplied by Black, Sivalls and Bryson, Inc., have been correlated in an effort to provide a basis on which to make such calculations for water-to-gas type heaters.

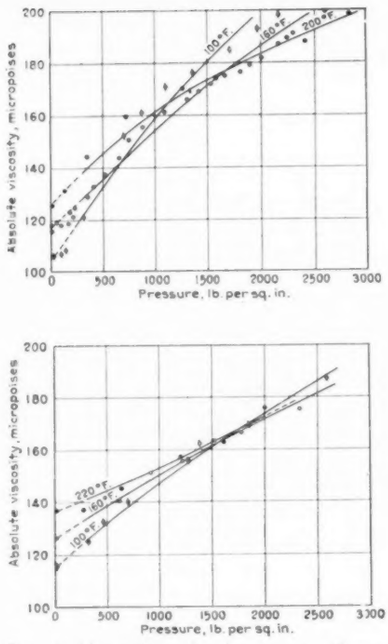


Fig. 6. Viscosity of a lean natural gas (upper). Viscosity of methane as a function of pressure (lower)

(From B. H. Sage and W. N. Lacey: Transactions A.I.M.E., 1938, Vol. 127, pp. 118-134).

Correlation. Though some of the heat transfer coefficients listed are high, it appears that the gas film coefficient is the controlling factor. On this assumption, an effort to correlate U with the gas stream conditions is presented. The pressures and mass velocities under consideration preclude the use of the customary equations, so the factors of specific heat, viscosity, and Reynold's Number were considered. The data were plotted on log paper with the results shown in Fig. 7. The resulting equation is:

$$\frac{U}{C_p\mu} = 0.00104\ Re^{0.228}.$$

It may well be that such a correlation is not entirely satisfactory in all heaters; however, it is presented for what it may be worth.

Conclusion

Sufficient physical data are now available to study gas heaters on a theoretical basis. The present difficulty is the lack of data on actual heaters. It is to be hoped that more actual heater data will be available in the future.

Summary

This article concerns the heating of gas at the wellhead when a pressure reduction is made that would otherwise cause freezing. The data presented are not limited, however, to this specific use. The necessary physical data for design and analytical purposes are presented first, and are followed by actual heater data. Pressure drop calculations, for which Weymouth's formula does not hold, are also discussed.

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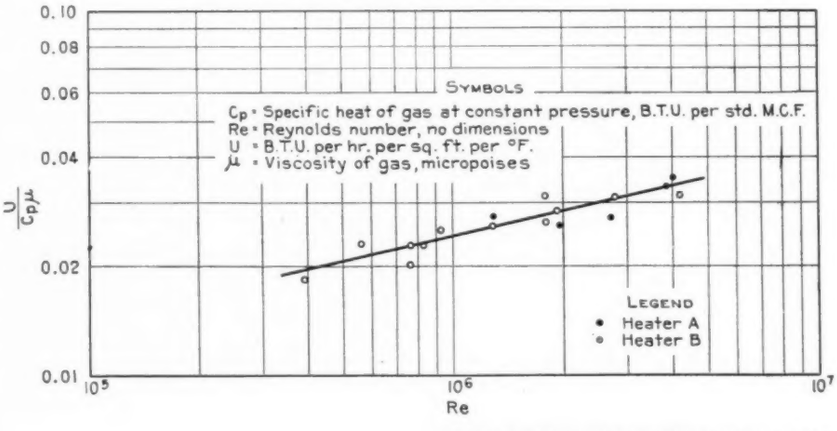
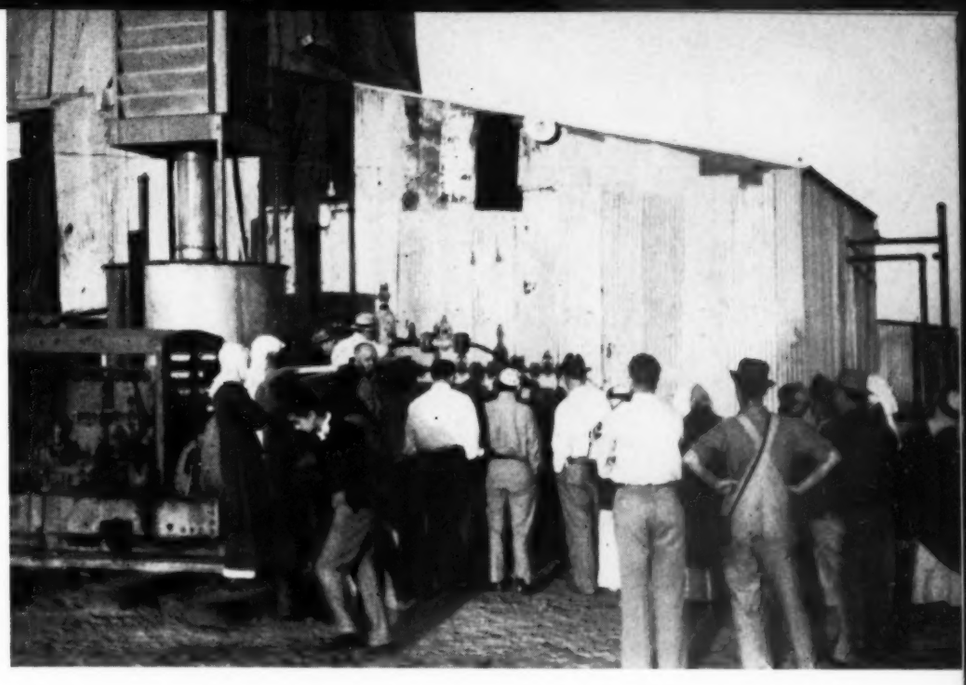
Fig. 7. Rate of heat transfer in gas heaters


Symbols
Cp = Specific heat of gas at constant pressure, B.T.U. per std. M.C.F.
Re = Reynolds number, no dimensions
U = B.T.U. per hr. per sq. ft. per °F.
μ = Viscosity of gas, micropoises
Legend
Heater A
Heater B
U/Cpμ
Re

P 425.
P 148.

A group of interested onlookers waiting for the discovery well in Abu Hadriya, Saudi Arabia, to be brought-in



A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By

E. E. SANDERS

Saudi Arabia Deep Well Drilled With Modern Equipment

Inaccessibility of well's location and hard formations from grass roots down among difficulties encountered in drilling 10,220-ft. discovery in Abu Hadriya—Close control of mud weight and viscosity made necessary by high gas pressures and danger of losing circulation

FOREWORD

IT is intended in this article to convey to the reader a picture of some of the adverse drilling conditions encountered in Saudi Arabia, particularly those connected with wildcatting. It is a tribute to the California Arabian Standard Oil Company that the success attained has been achieved in the face of almost insuperable difficulties that have required courage and dogged perseverance to overcome.

In April, 1940, in Abu Hadriya, Saudi Arabia, a wildcat well was brought-in at a depth of 10,220 ft. This well is more than 100 miles from any other production and is regarded as an important discovery. The total thickness of the oil sand is unknown because only about 110 ft. was penetrated. The formation penetrated in this well checked closely with those in the producing wells of the main camp at Dhahran, but with this exception: at Dhahran production is found a short distance below the main body of anhydrite; but in Abu Hadriya, more than 2000 ft. was drilled below the main body of anhydrite before the pay sand was struck. The general characteristics determined in tests made of ditch samples were comparable with those found in a wildcat well in The Peninsula of The Persian Gulf, almost 200 miles away.

E. E. SANDERS

has been active in the drilling of oil wells for a period of 20 years—His early experience was in Oklahoma, Texas, Arkansas, and California—Spent seven years with Tropical Oil Company in Colombia, South America, beginning in 1924—Worked in Bahrein Island for Bahrein Petroleum Company for 16 months, at the end of that time being transferred to the California Arabian Standard Oil Company and sent to Saudi Arabia to work on the wildcat operation discussed in this article—Is now in California and expects either to return to the Near East or South America.

After thousands of dollars and 18 months' time had been spent, the hole was about to be abandoned when a marked change in formation was observed and 70 ft. of hole was made in a few minutes. An examination of the cuttings circulated from the hole told the story. A production test was made with a fluid tester equipped with a straight-hole packer, the well being allowed to flow through the drill pipe. The test was satisfactory and showed clean oil. After several days of constant flow the well was shut-in at 1550-lb. pressure.

The drilling unit and complete equipment used on the well at Abu Hadriya, including the most up-to-date camp facilities, were unloaded from a freighter on the docks at Basra, Iraq. Each item relative to living conditions, transportation, and drilling equipment was chosen after long deliberation. At the time the location had been decided upon in the Abu Hadriya section, the drilling equipment was not on hand to drill a deep test.

Ocean-going vessels could not dock at any point near Abu Hadriya, so it was necessary to transfer all equipment

A part of the crew that drilled the well

from a freighter to barges and tow them up the coast to Manifa, which is about 18 miles from the camp site. Docking facilities had to be constructed at Manifa at a cost of about $15,000. When this was completed, the work of unloading and trucking to the camp site was begun. The work began in the summer of 1938. Most of the Americans on the job were recent arrivals in Arabia and suffered from the intense heat while air-conditioned houses were being erected. The bunk houses, storehouses, garage, and power house were sectional and this facilitated speedy erection.

The magnitude and expense of a venture of this kind are enormous. Roads have to be built, pipe lines laid, sanitary facilities installed, and water provided for both domestic and industrial uses. The latter entails the drilling of water wells. Provision must be made to house not only the few Americans but several hundred Saudi Arabs and Indians. The native personnel was reduced after the camp was completed, the derrick constructed, and actual drilling had begun.

A 122-ft. derrick was used and necessitated caution on the part of the drillers because of the restricted clearance between the traveling block and the crown block. Although 90-ft. stands of drill pipe, and a 300-ton hook on a 66-in., 5-sheave traveling block were employed, there was no record of the crown block being bumped at any time during the 18 months of drilling.

The rig was equipped with two 7¾-in. by 16-in. power-driven mud pumps. Each was driven by a 200-hp. Diesel engine that operated at a maximum speed of 800 r.p.m. Although a capable Diesel mechanic was available 24 hours per day, repairs and adjustments on these power units were negligible. The pumps were equipped with dual flexible hoses for compounding and worked under pressures ranging from 400 lb. to 2000 lb., depending on depth of hole and the size of drill pipe and liners. During completion of the well and when it had to be killed after the final production tests were made, a pressure was applied equivalent to the shut-in pressure of the well (1550 lb); the necessary valve was opened, and the pump pressure increased to 2000 lb. This operation apparently resulted in no damage to either pumps or power units. The pressure diminished immediately as the oil was forced back into the formation and heavy mud filled the hole.

The 8-speed drawworks was powered by two 200-hp. Diesel engines. The engine hook-up was such that either one or both engines could be used, depending on the power required. It was proved on several occasions that with the gear ratio of the 8-speed drawworks, one engine was sufficient in an emergency to pull 10,000 ft. of 3½-in. drill pipe from the hole. This equipment was designed for a 12,000-ft. hole and would easily have drilled to that depth without additional changes.

The formations encountered from the grass roots down are comparatively hard and three-way rock bits were used exclusively. A weight indicator was used on the well. Carrying minimum weight and rotating the table at about 130 r.p.m. were found to be satisfactory and lessened the likelihood of fishing jobs. Hydraulically-operated blowout preventers, of 6000-lb. test, were employed during the entire drilling of the well.

Principal among the major items of expense in drilling operations in Arabia is mud. Native mud is used to some extent but, although it is inexpensive and can be utilized in shallow hole, it is unsatisfactory when gas zones are reached. These warrant extreme caution because of gas pressure. The maximum weight of native mud is 72 lb. per cu. ft. A commercial preparation of barytes was used in large quantities and the bentonitic mixture employed to provide colloidal properties had to be watched carefully. Close supervision of the mud day and night is important because of the importance mud plays in the successful drilling of an oil well, even in Arabia.

Loss of circulation occurred in practically every well drilled on Bahrein Island and also in those drilled in the main camp at Dhahran on the mainland. The drillers on the Abu Hadriya well were expecting to lose circulation at any depth after the well was spudded-in. The loss of circulation, besides being expensive, is dangerous if it occurs below a zone of high-pressure gas. It was necessary to watch the weight and viscosity of the mud constantly. Two trained men were on the job at all times. Circulation was never lost at Abu Hadriya and this fact indicated that the subsurface conditions were different from any yet discovered in Arabia.

As in most wildcats in foreign fields, the progress of the well at Abu Hadriya was of necessity slow. Coring and testing were long, drawn-out operations. The main base of supplies being more than 100 miles away, arrangements were made in advance to meet every emergency. A two-way radio facilitated the prompt delivery of essential supplies and equipment. Although the newly built desert road was not of the best, it sufficed for large trucks to deliver pipe and heavy equipment and was a much faster means of transportation than the towing of barges up the coast, as was done in the beginning. There was always the possibility of a truck driver becoming lost in a windstorm or stuck in the mud. Everyone was required to check-in at the radio stations upon leaving or arriving. In this manner, if a truck or light car became several hours overdue, a searching party was sent out. Transportation problems have been overcome to a remarkable extent in Arabia, when the type of drivers available is taken into account. Native drivers are trained very patiently and, considering everything, the field men operating the transport units have done a good job. Loading and unloading heavy equipment must be personally supervised by an experienced American.

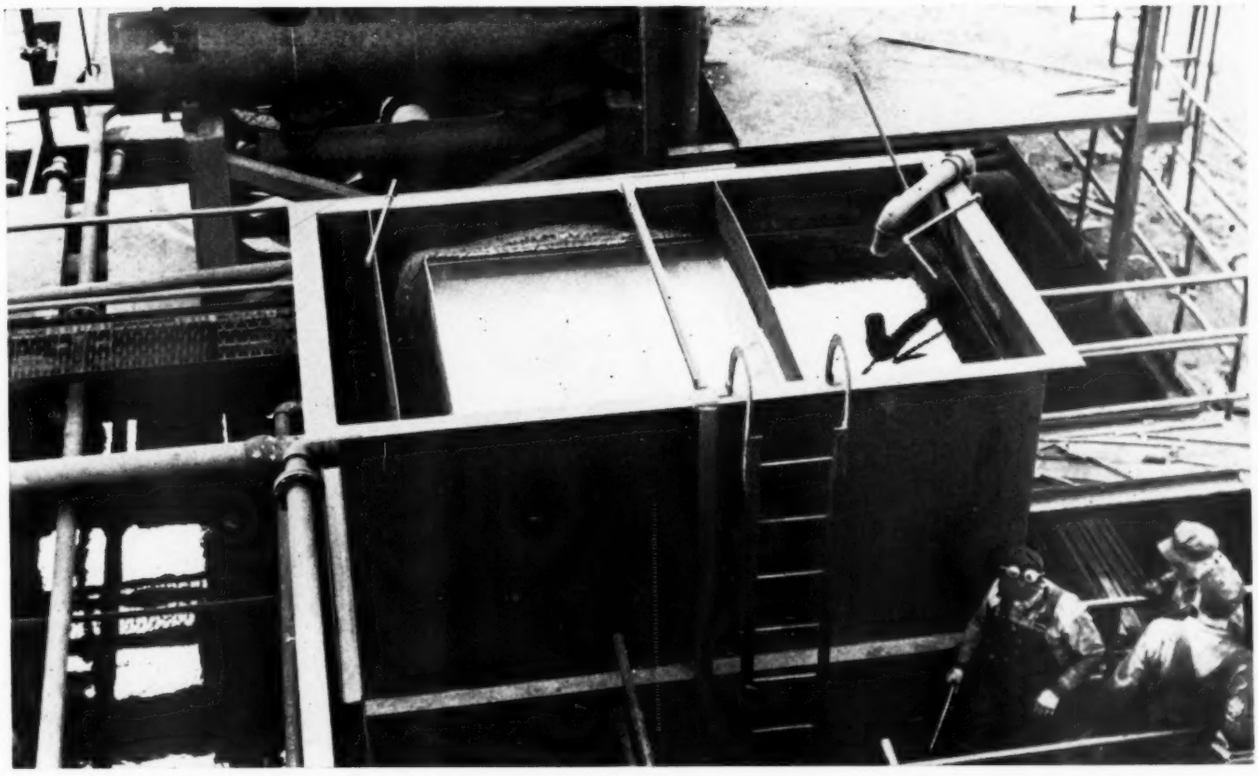


Fig. 1. Water-treating unit wherein water is conditioned by the use of aeration, sulphuric acid, and colloid
(Photo Courtesy W. H. and L. D. Betz)

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Developments in Treatment of Refinery Water

Ionic control, removal of corrosive ingredients, and maintenance of pH are objectives of modern treating methods

By ARCH L. FOSTER
The Lubri-Zol Corporation, Cleveland, Ohio

THE art and science of purifying water used in the refinery is a task on the results of which much of the refiner's economy hinges. Inasmuch as the refinery is definitely a chemical factory in the broader sense, it follows that not only must boiler water be treated but in many cases process water as well must be put into condition so that it aids rather than hinders the ticklish job of chemically treating the numerous products. The quality of these products may be made or spoiled by a seemingly slight difference in the hardness of the water or in its ability to separate cleanly and without leaving undesirable impurities in the oil.

Many years ago when we were new in the refinery we remember hearing a boisterous, technically untutored but widely experienced old refinery foreman say, "We ain't makin' good lubes in this plant because we ain't got good water; when we git good water, we'll make good lube oils." It seemed a far cry then, to blame poor quality on that one item but as time went on the meaning of the old man's statement became clearer. Also, as a technical industry we now know far more about "gittin' good water" than we did then, especially for process purposes.

Elements of Water Treatment

Water treatment reduces to five essential reactions: Reduction of metallic or positive ions; reduction of negative or acidic ions; control of corrosion-producing ingredients; maintenance of the proper pH values to eliminate such troubles as embrittlement of boiler steel and the removal of suspended matter, algae, etc. The first two steps are accomplished by metathetical reactions, the exchange

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of ions causing trouble for others that are innocuous in the purpose for which the water is to be used. Corrosion is caused by the presence of the ions of strong acids such as nitric, sulphuric, hydrochloric, etc., by dissolved oxygen; the presence of carbon dioxide is also undesirable for the same reason. Maintenance of the desired pH values is necessary to control corrosion as well as the embrittlement that is caused by the presence of too high caustic content. Suspended matter such as organic material, mud, etc., may be expensive because of too frequent blowdowns in boilers or may adversely affect the color, the purity, or the cleanliness of the products. Suspended matter also has a very undesirable effect on the efficiency of other steps in the water-treating plant, especially with natural or synthetic zeolites.

Water-Treating Methods

The most common method of producing water suitable for boiler purposes is by the removal of the scale-producing calcium, magnesium, and, in some instances, iron from the water, by precipitation with caustic soda, lime, or other chemicals that substitute comparatively harmless ions for these deletorious products. Calcium occurs as bicarbonate or temporary hardness [$Ca(HCO_3)_2$], calcium sulphate or permanent hardness ($CaSO_4$), and may sometimes be found as calcium chloride. Magnesium occurs as the salt of these same acids, as does iron, although the amount of iron usually present in most waters is small. Calcium bicarbonate, when heated, decomposes to the carbonate, $CaCO_3$, a highly insoluble material, and releases a molecule of water and one of carbon dioxide, CO_2; the latter being, of course, undesirable from a corrosion standpoint. $CaCO_3$ is probably the worst scale-former in the Periodic System and unfortunately the occurrence of the bicarbonate in surface waters and more especially in underground waters is more than common.

One of the oldest methods for "softening" boiler water is by treatment with lime, CaO, and soda ash, Na_2O. In the water the soda becomes caustic soda, $Na_2O+H_2O=2NaOH$. The sodium ion displaces the calcium from calcium sulphate, forming sodium sulphate and calcium hydroxide, $Ca(OH)_2$, also only slightly soluble in the water and which largely precipitates in the treating plant. The lime combines with the calcium bicarbonate to form the carbonate, which precipitates also, and the two reactions leave sodium carbonate and sulphate in the water instead of the scale-forming calcium salts. Sodium carbonate in excessive amounts promotes foaming and priming in the boiler as well as steel embrittlement, the latter because of the fact that a strong basic ion like sodium, combined with a weak acid ion like carbonic acid has a decidedly basic reaction, as the base is strongly ionized in solution but the weak acid is only slightly ionized. Most waters containing either temporary or permanent hardness, however, may be softened with lime and soda without formation of too much sodium carbonate.

Lime-soda and so-called zeolite methods are often referred to as external treating methods. Other methods, known as internal methods, include treatment with sodium aluminate, phosphates, sodium silicate, and organic and colloidal reagents that will be discussed later. The zeolite is a natural or synthetic mineral containing, for example, sodium silicate as one of its main constituents, which is used in a solid form, as in the common greensand widely used for boiler water treatment. The zeolite is placed in a cylinder or other convenient container, supported on a screen and water is pumped through it, usually percolating downward. The scale-forming ions are exchanged for the sodium ions of the zeolite, removing the calcium and magnesium. When chemical test shows that the zeolite is becoming exhausted, sodium chloride solution is pumped through the treating container in reverse flow, thus displacing the scale-forming ions in turn by the sodium ions of the NaCl solution, to regenerate the zeolite. In this manner of alternate treating and regeneration, the zeolite can be used indefinitely, until such time as it becomes fouled with foreign matter or its physical structrue is destroyed by injudicious handling.

Betz (*National Petroleum News*, April 6, 1938, p. R-167) shows that the cost of zeolite treating to soften a water containing 460 p.p.m. of hardness is slightly more than 8 cents per 1000 gal. of water treated. The investment cost for greensand to treat 720,000 gal. per day is approximately $30,000.

Water containing more than traces of suspended matter must be filtered before it reaches the zeolite bed, otherwise the efficiency of the zeolite is permanently impaired (Hull, *National Petroleum News*, February 22, 1939, p. R-72). Furthermore, high temperatures in the raw water will damage the zeolite bed, breaking-down the physical structure of the grains and destroying its usefulness. Water must be passed through the zeolite, therefore, before much preheating has been done, 150° F. being about the highest practicable temperature with lower temperatures preferred.

The use of sulphuric acid followed by treatment with organic colloids has been found to be low in cost and serviceable in situations where this method is applicable (Betz, loc. cit.). Stating that it is not desirable to eliminate all the carbonate ions because of possible corrosion, a water containing 200 p.p.m. of carbonate hardness as calcium bicarbonate may be treated to eliminate 160 p.p.m., leaving 40 parts to maintain the desired pH value in the water. The sulphuric acid forms calcium sulphate from the bicarbonate, releasing the bicarbonate ions, which must be eliminated as CO_2 from the water by heating. Calcium sulphate is more soluble than the carbonate. The acid must be added to the water under careful control to maintain the desired pH value, a proportioning pump being used most advantageously and the quantity added is governed by careful testing of the treated water to avoid adding too much acid and yet reduce the bicarbonate hardness to the required minimum value. Water so treated may be further conditioned by the use of organic colloids of the so-called "protective" type, which have the property of dispersing calcium and other ions that might otherwise tend to precipitate, forming crystals and eventually scale. Colloids used in treating water for other purposes will be discussed later.

The reactive colloids used for this purpose need be added only in small quantity, 0.1 lb. per 1000 gal. of water being required in the instance referred to above. Equipment required for this acid-and-colloid method is simple and economical, the total bill for this process being somewhat less than $400. Treating costs for this particular water referred to is calculated to be about 3¼ cents per 1000 gal., overall.

The use of sodium aluminate and similar chemicals may have the double advantage of removing hardness ions by chemical reaction and of flocculating suspended or colloidal material that is removed by settling and filtration through sand. Alum is added to the water, usually as it enters a tank or tower, the two are mixed thoroughly and the settled floc and sludge are partly removed from the bottom of the tower. Filtration through sand or other physical means removes the last traces of sludge. Dilute sulphuric acid may be added after this type of treatment to adjust the pH values as desired.

In many cases with turbid water,

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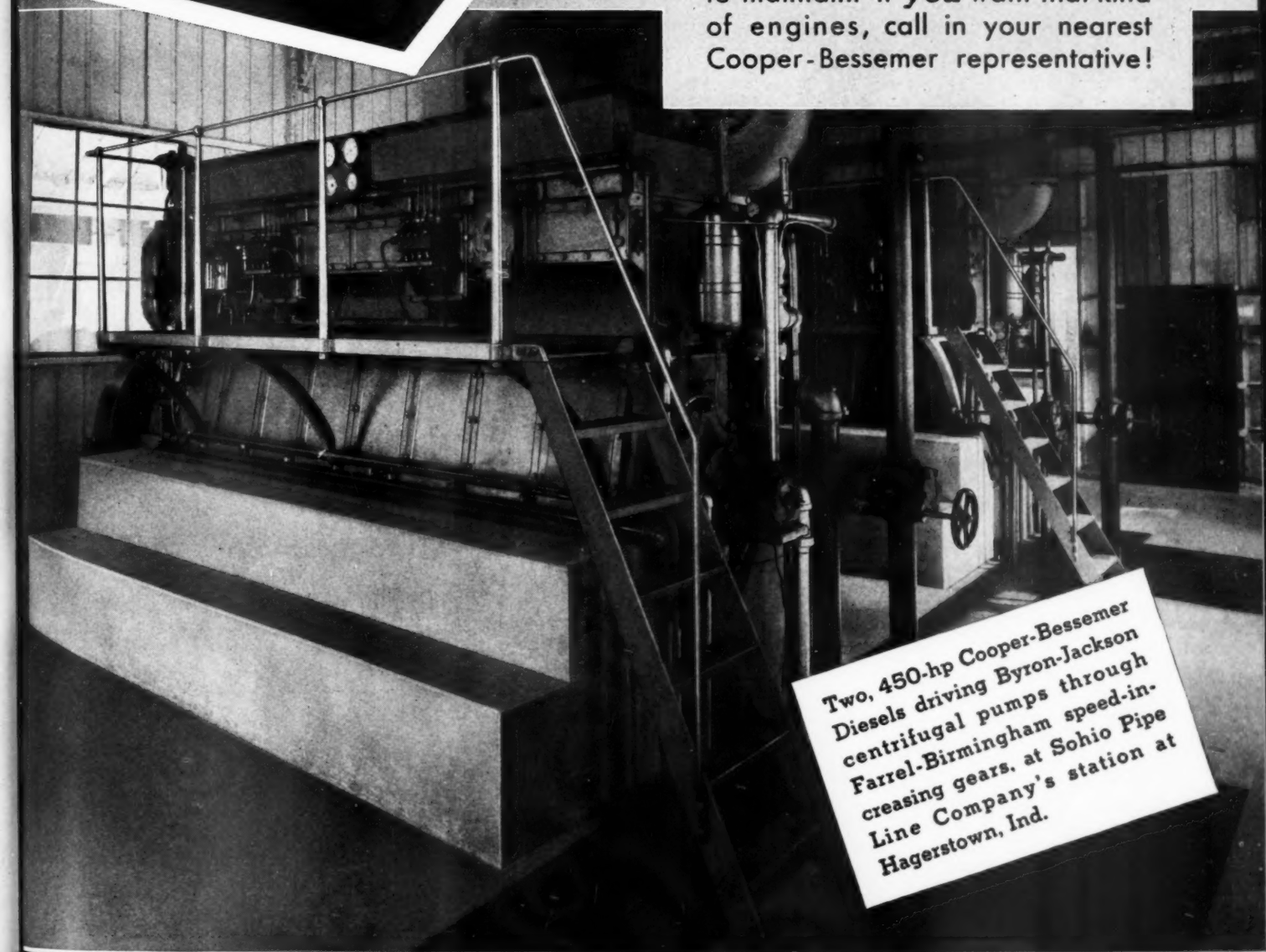

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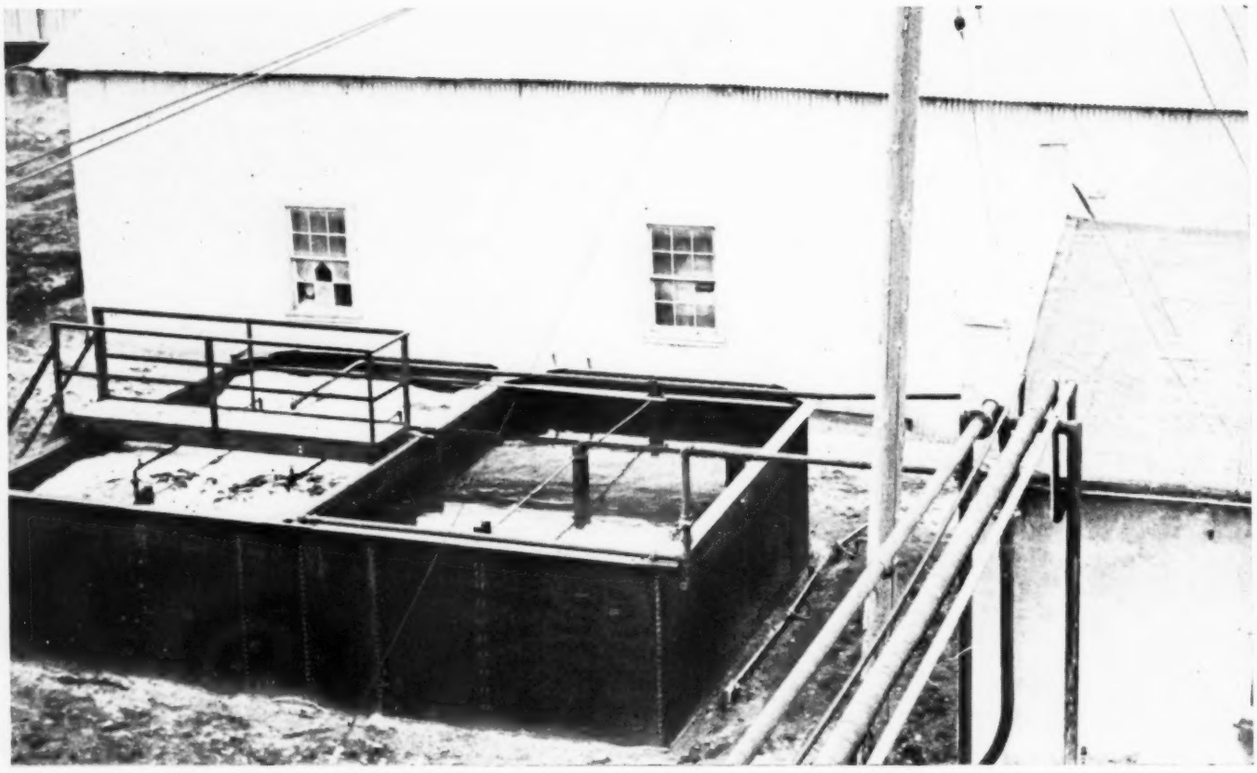

Fig. 2. A two-tank system for water conditioning
(Photo courtesy W. H. and L. D. Betz)

algae may be found to develop in storage or to be present in the raw water. Various methods are used to combat this trouble, which promotes sludge, foaming, and priming if allowed to go on in boiler feed waters. Copper sulphate has been employed to advantage, using merely enough to eliminate the algae growths, the amount needed being determined by test. Chlorination has also been employed satisfactorily for the same purpose. Chlorine is added until a slight trace of it is shown by the orthotolidine test on the water from the chlorinator unit.

A variation of the lime-soda method is the addition of phosphate to the mix. This has the advantage of permitting the use of water at higher temperatures, the hot process increasing the water temperature by heat exchange or otherwise to near the boiling point. Sodium sulphate is added also to guard against caustic embrittlement; disodium phosphate or hexameta-phosphate is needed, too, in the boiler to prevent scale formation from any such ions that may pass through the system. Sodium sulphite may be added to the water, after it has passed the heaters where most of the air, CO_2, and oxygen have been removed, to complete the final oxygen elimination.

Treatment With Colloids

The newest principle applied to water conditioning is that of treatment with colloids. Colloids are defined as a state of matter rather than a separate compound or type of product. The colloid is intermediate between materials in true solution, which are considered to be separated into single molecules, and materials in true suspension, which are microscopic in particle size that can be separated from liquids by gravity settling. Colloids pass through filters whereas suspensoids do not. Colloid particles vary in size from one micron (0.00004-in.) to one millimicron or one-thousandth of a micron, in diameter. A colloid particle is a cluster of several molecules, submicroscopic in size, discernible only by the use of the ultramicroscope. Colloidal solutions have the property of diffusing a beam of light passing through the solution, producing the Tyndall cone, an effect not shown by a true solution or by a suspension of solids in water. Under the ultramicroscope colloidal particles are observed to be in continual motion, a phenomenon called the Brownian movement, so-called because first discovered by a botanist named Brown in watching grains of pollen in liquid. This movement is considered to be due to the bombardment or hammering of the colloidal particles by the molecules of liquid in which the colloid is incorporated. Colloidal particles are often referred to as giant molecules.

Because of the tremendous increase in surface when a material is reduced to colloidal size particles, the chemical reactivity of that material is greatly increased. This is true to such a remarkable extent that we have built a separate branch of the science, called colloid chemistry. Reactions occur and may be carried out successfully in the colloidal state that either do not occur at all or take place at prohibitively slow rates in true solutions.

Colloidal particles in solution carry electrical charges, each individual material having a definite type of charge, either positive or negative. Scientists claim that several layers of charge are found on the colloid surface, all of the same sign, and that to these charges, more numerous than those carried by electrons, is due the greater chemical reactivity of the colloid particle. To these electrical charges the property of adsorption is credited, as adsorption is a surface reaction by which the particles attract other materials to themselves. Reducing 1 cu. cm. of solid to particles one ten-millionth of an in. in diameter yields a

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total surface of about 1.5 acres, it is calculated. One of the interesting industrial processes that is possible because of the electrically charged nature of colloids is that of depositing rubber from a colloidal solution of rubber in water on practically any type of material that may be used as an electrode, forming an impervious, closely adherent layer on the electrode surface.

In water treatment two types of colloids are employed. The protective type does enter into chemical reaction with other materials, but appears to form a coating or cover on the surface of very small crystals as they are formed, preventing their combining to form larger crystals and thus preventing precipitation from a given solution. Tannins and starches are examples of this type of colloid, which are used to deter crystal growth. They are hydrophobic, that is, water repellent, are positively charged, and will not react with polyvalent ions in solution.

Reactive colloids form chemical compounds with other materials, not in normal proportions such as appear in reactions between solutes in true solution, nor do they always form the same products of the same percentage composition with the same type of material. It appears that the colloid particle combines as a unit and acts as a single "operating" unit in reactions. These colloids are negatively charged, are hydrophilic, and may be peptized by addition of various salts. When brought into contact with polyvalent ions in water, such as calcium or magnesium, a reaction takes place, considered by colloid chemists to be a definite, reproducible chemical combination. The colloid absorbs the polyvalent ions to itself, at the rate of one bivalent ion for each two units of negative charge; therefore each particle can adsorb or react with several ions. This reaction forms a gel that precipitates, removing the ions from the system or solution. This gel or precipitate retains the property of adsorbing suspended materials, which it removes from suspension and carries down with it. Thus this type of colloid removes both dissolved and suspended materials at the same time. Among the materials are those of the laminaric acid series, which has been widely used for water conditioning.

Another type of reactive colloid may be used in solution or in the solid state to effect exchange of ions that it is desired to remove, such as polyvalent ions in water. Bird (Proc. A.S.T.M., June, 1938) shows that "cation exchange" bodies in the form of organic colloids may be used to remove scale-forming and other ions from water. One type of body is formed by the condensation of phenols with aldehydes and acids. It is believed that these bodies are reactive because of the presence of phenolic hydroxyls, and that the hydrogen of these groups is replaced by the positive ions such as calcium and magnesium in water solution, thus softening the water so treated. Another type of exchange material is made by treating lignite or using lignite as such. The reactivity of this product is believed to be due to the presence of humic acid, which reacts with the metal ions. Humic acid possesses the typical organic carboxyl group, — COOH, from which the hydrogen may be replaced by metals.

Sulphonic Acid Treatment

Still another exchange material is sulphonic in character, made by treating wood, coal, lignin, etc., with sulphuric acid to form sulphonic acids, which remove positive ions from water. Similar materials are used for the removal of negative ions from solution such as hydrochloric, nitric, and sulphuric acid ions. A unit for treating water with these materials may contain only a cation removal exchange if only the metals are to be removed, or may use both if removal of the acid ions is required.

The cation exchange material is used as a zeolite. Generally these substances are much lighter in weight than the inorganic zeolite, expand much more during regeneration by countercurrent flow and must be provided with greater free space above the bed for that reason, inasmuch as they expand five or six times as much as inorganic zeolites. For the same reason—that of light weight—the extra space above the bed for operation with upward flowing liquid must be provided to prevent incorporation of the exchange material in the outflowing water.

The exchange material is regenerated with acid to remove the metallic ions previously picked up from the treated liquid. During softening operations the softened water will pass from the exchanger unit free from positive ions—except hydrogen—but will contain acid ions equal to the amount of bases removed in the treatment. These acid ions may be neutralized by addition of bases such as soda or other alkalies, alkaline water, or other means to correct the pH values to the desired point. Or, the acid water may be treated next with other colloidal organic exchange materials to neutralize it. These exchange products are basic in reaction, combining with the acidic ions in the water. One type of such exchange material is formed by condensation of an aldehyde and an acid with an aromatic amine, a homologue of aniline or aniline itself, $C_6H_5 — NH_2$. A halogen, such as chlorine or bromine, also may be added to a suitable base material, after which this is reacted with an amine. A good reagent of this type will have a capacity of more than 6000 grains of acid per cu. ft. of material when absorbing hydrochloric acid, and will absorb 2½ times that equivalent amount of sulphuric acid. The absorption of carbon dioxide from solution is not efficient. As this weak acid is broken up and the gas dispersed by heating the water after treating, however, no problems arise because of the poor capacity of the exchanger material for it.

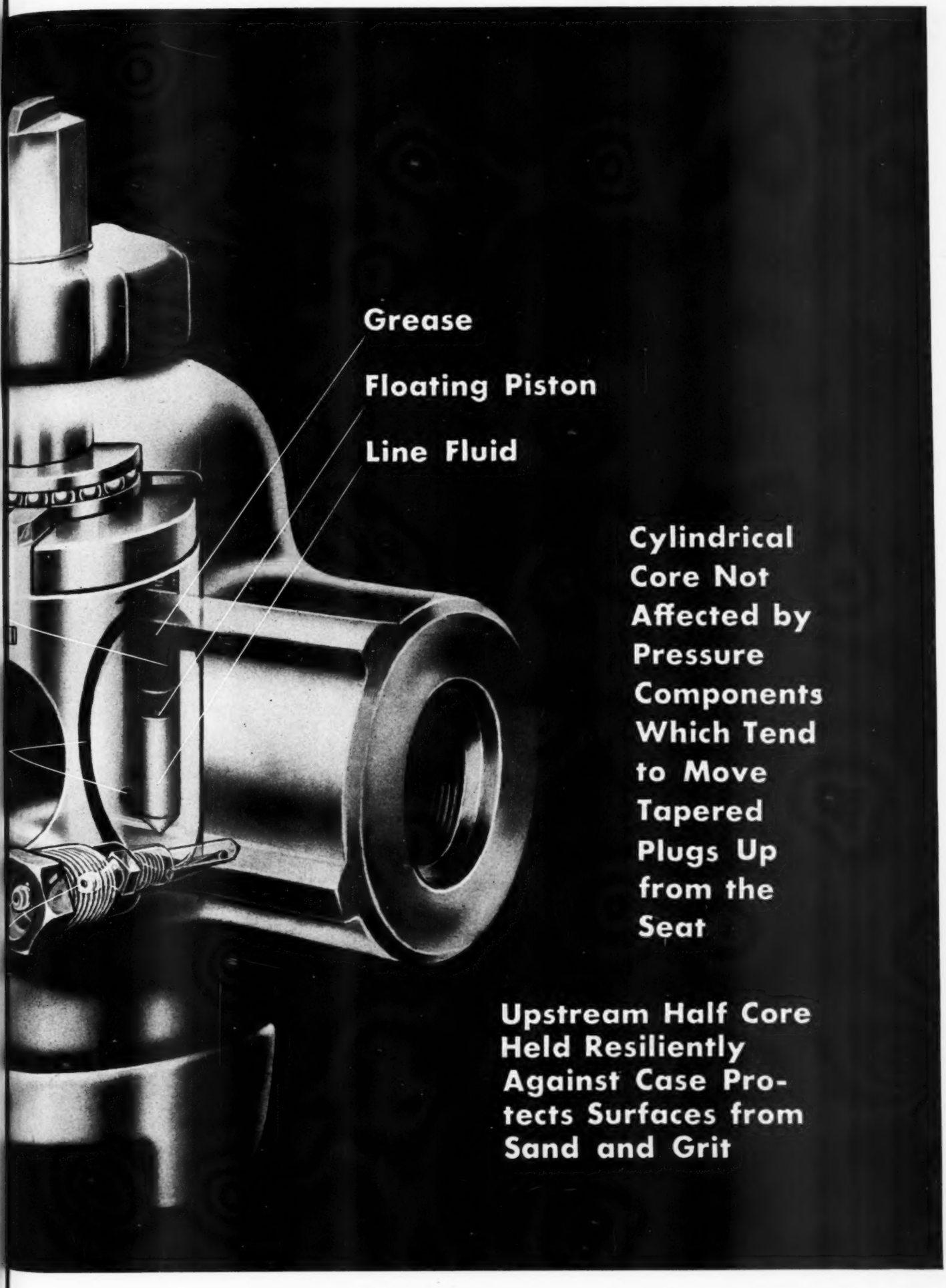
The acid exchange body is regenerated by the introduction of caustic solution to the bed. A chemical efficiency of 75-80 percent is obtainable, as compared to that of inorganic zeolites of 33-34 percent when regenerated with sodium chloride.

Regenerating solutions for both types of organic exchange bodies should be dilute. Acid solutions of ½ to 4 percent have been used, with better efficiency from the more dilute solutions. Caustic solutions as low as 1 percent or lower show good results, and regeneration of a bed of either type can be completed in 1½ hr. Beds must be washed carefully after regeneration, removal of excess caustic requiring the greater length of time and amounts of water. Control of regeneration as well as treating is maintained by testing the outflowing water, to determine when the unit is no longer removing the desired ions when treating and to find out when the regenerating ions, acid or base, are "coming through" unreacted during regeneration. Control of pH values of the water from both types of treatment is governed by values found to be most efficient by experience, as is discussed in the following paragraphs.

Hydrogen Ion Concentration

The concentration of hydrogen ions, that is, pH values, in treating water, that may be required for the best results in steam generation or in process work and for the most efficient treating results is determined by careful experience. In treating with alum to reduce turbidity in water, it was determined several years ago (Hatfield, *Ind. Eng. Chem., 14,* 1038, 1922) that flocculation is best between pH of 6.6 and 7.6 in treating water containing 200 p.p.m. or more of hardness. With highly alkaline waters, some of the alum may be consumed in reducing the alkalinity. Other writers have found that a pH value of about 6.0 is most satisfactory when using alum. When

(Continued on Page 42)


Grease
Floating Piston
Line Fluid
Cylindrical Core Not Affected by Pressure Components Which Tend to Move Tapered Plugs Up from the Seat
Upstream Half Core Held Resiliently Against Case Protects Surfaces from Sand and Grit

(Continued from Page 38)
removing silicic acid (hydrated silica) with alum, a pH of about 8.0 was found satisfactory by Smith (*J. Am. Chem. Soc.*, *42*, 460, [1920]).

For Western and other waters high in hardness, ferrous sulphate and lime at high pH values have been found successful, using phenolphthalein as an indicator. Miller (Public Health Reports, 1923) found that between pH values of 6.7 and 7.0 the insolubility of aluminum floc is at its highest value, that is, the floc is preciptated best in that range. Sulphates are brought down with the floc under these conditions in the largest percentages. Miller also found that polyvalent ions are better agents for coagulating suspended or dissolved matter. Sulphate ions produce good flocculation over a wide pH range. These findings were corroborated in part at least by Clark and Thierault (Public Health Reports, 1923), who found that in dilute solutions, that is, water with relatively low hardness, the best pH value is about 5.5. The optimum range is narrow, not greater than about 0.3 pH value.

Summary of the findings of different investigators shows that in treating water containing differing amounts of materials, precipitation occurs at different pH values. Three variables must be controlled properly if water is to be clarified satisfactorily: (1) The pH value must be definite and at the optimum, (2) aluminum ion concentration must be held at the lowest practicable value, (3) a strong anion, sulphate, for example, must be present. Sulphate ions are known to change the flocculation point to the acid side of the pH rating, but carbonates have little effect even in concentrations as high as 500 p.p.m. The same is true of chlorides (Hopkins, *Ind. Eng. Chem.*, 32, 263, [1940]).

Water coagulated at the most efficient pH value settles in minimum time. Rapid mixing of reagent and water at the beginning, followed by a gradual reduction in the rate of agitation, and also an extension of the mixing time promote the best and most complete precipitation and settling of the sediment. Quickly bringing the water into intimate contact with the reagent, followed by long agitation to obtain maximum "clumping" or agglomerating action forms larger particles of floc that settle faster. Maintenance of the most efficient pH concentration for any given water and any given reagent concentration is a paramount factor in completing the water clarification process.

Glucoside-Glucosate Methods

Another type of organic products useful for water conditioning is that of the glucosides and metallic salts of these, called glucosates. A glucoside is the combination of an alcohol with the carbonyl group of a saccharose (sugar) such as glucose, levulose, etc. Hydrogen atoms in these glucoside molecules may be substituted by a metal such as sodium or chromium; by phosphorus, sulphur, and other elements, each combination possessing in varying degrees certain reactive effects on water impurities.

The first organic material to be used in water control was potatoes, from which a twofold reaction was obtained. The peel of the potato appears to yield a glucoside, useful in preventing scale, reducing alkalinity, etc.; the starch probably acts as a protective colloid to prevent solid precipitation and scale formation. The practice is not economical or efficient, however. Other materials are used; tannins, which are glucosides, molasses, starch, dextrin, the sugar beet, and various resins. These products are either unstable and may set up undesirable side reactions, or are inefficient, giving incomplete reactions or requiring too much material to warrant their use in competition with other and cheaper methods. Tannin is probably the best of the list, forming soluble tannates, the hydrolysis of which may also form soluble magnesium and calcium salts. (*Organic Methods For Corrosion Control*, Haering and Company, Chicago, Illinois.)

Glucosides may remove excess alkalinity by direct reaction with the hydroxyl ion. Sodium sulpho-glucosate removes oxygen quantitatively, and at the same time the sulphate content of the water is increased. Sodium phospho-glucosate is employed to control pH values and to serve as protection against caustic embrittlement. Dissolved or suspended solids that cause foaming, etc., may be removed by absorption of solutes in the glucosate gel and by adsorption of suspended matter in the same material. Space is not available to give quantities required for any purpose. Accurate analyses and control methods are employed in each individual case to determine the amounts and methods of treating, and the specific product or combination of materials required.

P 099.

Proper Foundation Important in Minimizing Machinery Vibration

By W. F. SCHAPHORST

THERE are few machines that do not vibrate to some extent. All machines carrying high-speed rotating or reciprocating parts vibrate. Perfect balancing is impossible. To counterbalance or absorb these vibrations a foundation is usually necessary. But foundations, too, have what is known as a "natural period of vibration." A large massive foundation, of course, has a lower period of vibration than a small one.

It is logical, then, that if a foundation builder should happen to put a foundation under a machine whose period of vibration is identical with the period of vibration of the foundation, conditions would be made worse rather than better. The vibrations of the machine would be transmitted to the foundation and together the vibrations might become extremely violent. The period of vibration of a foundation must never be the same as that of the machine it supports. Thus machines are sometimes blamed for annoying noises and vibrations when they really are not solely to blame at all. Often the trouble lies more in the foundation.

One of the most effective modern methods for eliminating vibration and noise troubles is to isolate the machine from the building or from the ground by means of a strong resilient material. Natural cork is usually specified. Cork has a natural period of vibration that is invariably different from that of any machine. It is almost perfectly elastic during a long period of years. That is, it does not rot, warp, swell or shrink. From almost every viewpoint natural cork is an ideal material for machine isolation. Sometimes the cork is placed directly under the machine on top of the foundation, and at other times the foundation itself rests on the cork, depending upon conditions. Usually machinery isolation is a job for an isolation engineer who has had broad experience with all types of vibrating and noisy machinery.

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Prevention of Corrosion in Water-Cooling Systems

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Physical deaeration employing natural gas to displace oxygen from water reduces corrosion in compressor station cooling system

By E. G. HAMMERSCHMIDT
Chief Chemist, Texoma Natural Gas Company

TWO deep wells supply the water for the Natural Gas Pipeline Company of America compressor station near Geneseo, Illinois. Completed in March, 1932, these wells were drilled to a total depth of 1315 ft. and were cased to 517 ft. The rated capacity of each well is 200 gal. per min. A typical analysis of the water is given in Table 1. The raw water is passed through a zeolite softener and thence to the top of a cooling tower. The downward passage of the water through the tower gives sufficient aeration to remove practically all hydrogen sulphide. The water is then used in a recirculating system for cooling engine jackets and after-cooler coils.

TABLE 1
Raw water analysis

	Content, parts per million
Bicarbonate (HCO_3)	316
Chlorides (Cl)	602
Sulphates (SO_4)	366
Calcium (Ca)	106
Magnesium (Mg)	53
Hydrogen sulphide (H_2S)	10
Total dissolved solids	1723
pH	6.9

The water has proved to be very corrosive to iron and steel, especially at points of high velocity such as in the piston water service rods of the 1250-hp. gas compressor units. Representative of this type of corrosion is a fairly uniform but deep etching of the metal and scattered pitting and cavitation. The etched metal appears similar to the effect that is produced when steel is immersed in a strong acid.

The reason for the abnormally corrosive conditions at this particular compressor station is believed to be a combination of several factors. When iron and steel piping are exposed to the weather, e.g., rain and air, a coating of rust soon forms over the metal. The coating is protective in that it greatly retards the action of the air and water on the metal. This type of corrosion may be considerably altered by the kind of water to which the metal is exposed. For example, natural waters contain varying amounts of dissolved salts such as calcium and magnesium bicarbonates, calcium and magnesium sulphates, magnesium and sodium chlorides, etc. The bicarbonate ion tends to check corrosion but the chloride and, to a lesser extent, the sulphate ions tend to increase corrosion, the theory being that the chloride and sulphate ions will destroy the protective character of a film by bursting through and undermining the layer.[1] Sulphide films may also fail to prevent attack and sometimes they greatly accelerate the attack upon iron or brass.[2]

E. G. HAMMERSCHMIDT

is a graduate chemical engineer (1923) from the University of Iowa—Was plant chemist and assistant superintendent of natural gasoline plants for Cities Service Company at Caney, Kansas, and Madison, Kansas, until 1926—Conducted chemical research in natural gas and gasoline at Oil Hill, Kansas, and Tallant, Oklahoma, for Cities Service until 1931—Has been chief chemist for Texoma Natural Gas Company, Fritch, Texas, from 1931 to date—Has written for various trade publications and has presented technical papers before numerous oil and gas associations—One of his papers, "Preventing and Removing Gas Hydrate Formations in Natural Gas Pipe Lines," presented before the American Gas Association, Tulsa, Oklahoma, May, 1939, was awarded the Beal Medal.

[1] *The Corrosion of Metals*, by U. R. Evans, Edward Arnold & Co. (1926).
[2] *Metallic Corrosion Passivity and Protection*, by U. R. Evans, Edward Arnold & Co. (1937).

Corrective Measures

In theory, when iron is immersed in a solution of an oxidizing agent, such as potassium chromate, or in a fairly concentrated solution of an alkaline salt such as sodium carbonate, it does not corrode even though oxygen is present. The metal becomes passive. In actual practice, the addition of good inhibitors will usually reduce the amount of total corrosion but there is a danger that they may localize whatever corrosion still occurs upon a limited area and actually increase the damage done. This danger is increased by the presence of the chloride ion in the water.[1] Prevention of corrosion at the Geneseo station was first attempted by the application of an inhibitor of the chromate type. The results obtained were typical of the general case just mentioned and the treatment with inhibitor was therefore abandoned.

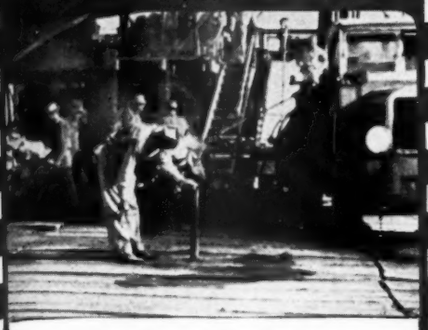
A consideration of the various corrective measures for combating this type of corrosion indicates that the following two are the most often effective: (1) maintenance of high pH value and (2) removal of dissolved oxygen. The pH of the Geneseo station raw water is increased during the softening and aerating cycle so that the resulting pH of the system water is 8.2 to 8.8. The pH of the system water, therefore, does not appear to be an important cause of corrosiveness. On the other hand, the water is satu-

TABLE 2
Removal of dissolved oxygen by gasification—Laboratory tests

Gas-water ratio (cu. ft. gas per gal. water)	Residual oxygen, p.p.m.	Percent oxygen removal
0	8.26	0
0.064	0.14	98.3
0.165	0.07	99.2
0.488	0.07	99.2

TABLE 3
Composition of fuel gas supply

	Percent
Hydrogen sulphide	nil
Oxygen	nil
Nitrogen	6.33
Carbon dioxide	0.15
Methane	84.70
Ethane	4.92
Propane	2.92
Butanes	0.93
Pentanes plus	0.05
	100.00



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rated with air each time it passes through the cooling tower.

Many devices have been developed for the removal of oxygen and other dissolved gases from aggressive waters by physical methods that are based on: (1) Dalton's law, which states that the pressure of a gas mixture equals the sum of the pressures of the constituent gases, and (2) Henry's law, which states that the amount of gas dissolved in a liquid is proportional to the pressure of the gas. Mechanical deaerators of this type are commonly used for the degassing of boiler feedwaters. This is usually accomplished by a preliminary heating of the water, sometimes under reduced pressure. Mechanical deaerators have also been used to some extent for the treatment of waters entering a pipe-line system. A notable example has been described by S. T. Powell and H. S. Burns.[3] A pipe line that was designed to carry 4,000,000 gal. per day of raw Mississippi River water a distance of nine miles, to the point of use, suffered a rapid loss of capacity due to oxygen corrosion. The economic solution of this corrosion problem was obtained by a combination of physical and chemical deaeration. Ninety-five percent of the dissolved oxygen was removed from the water by passing it through a slat-packed vacuum tower operated at an absolute pressure of 1.5 in. of mercury. The residual 5 percent oxygen was removed by the addition of sodium sulphite. This deaeration plant has operated successfully since 1935.

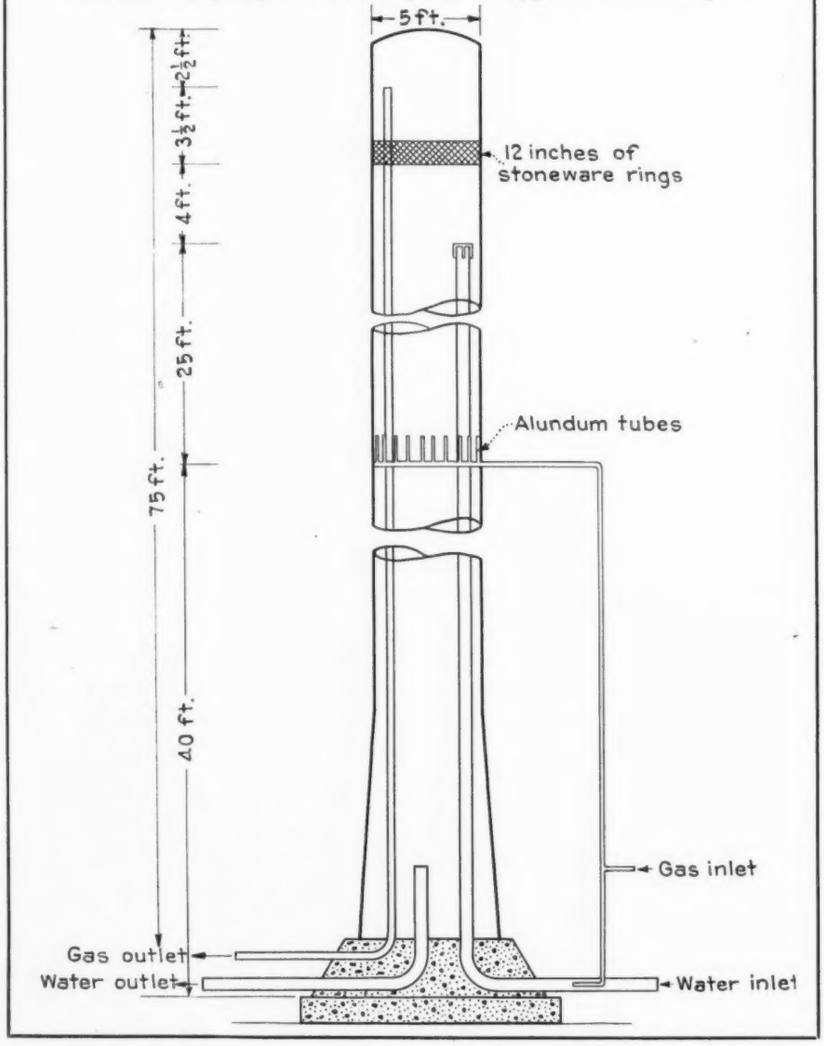
[3] Powell and Burns, *Chem. & Met. Eng.* 43, No. 4. April, 1936, p. 317.

TABLE 4

Average operating data—Pilot plant

	Zeolite-treated water		System water, Gasified	Raw well water	
	Gasified	Aerated		Gasified	Aerated
Hr. per day operated	23.8	23.6	23.5	8.5	8.5
Gas or air passed through columns, cu. ft. per day	679	497	634	237	199
Water passed through columns, gal. per day	1419	1382	1407	503	492
Ratio: cu. ft. gas or air per gal. water	0.479	0.360	0.451	0.471	0.404
Total hr. operation	1000	992	989	358	358
pH	7.9	8.1	9.0	7.9	8.1

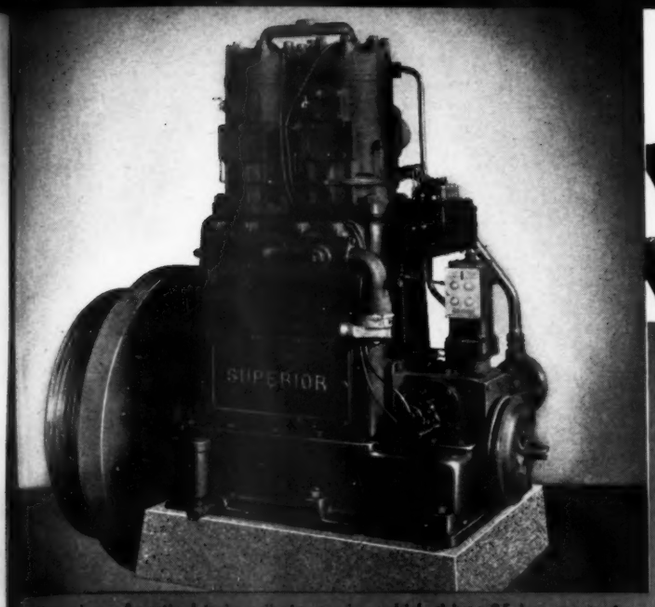
Fig. 1. Cross-sectional sketch of tower constructed at Geneseo station to deaerate engine jacket water by use of oxygen-free natural gas



Pilot Plant Experiments

The results of a series of laboratory experiments indicated that deaeration of the Geneseo station water would inhibit corrosion. Further study showed that deaeration of the engine jacket water could be accomplished by intimately contacting the water with an oxygen-free gas such as the natural gas fuel supply at the station (Table 3). In one of the experiments, natural gas was atomized by passing it through an alundum thimble. The atomized gas was then passed through a measured quantity of air-saturated water and thence through a meter. The residual oxygen in the water was determined by a modified Winkler method. The results (Table 2) indicated that it would be practical to remove at least 99.2 percent of the oxygen by this method, as the ratio of available fuel gas to the circulating system water was greater than the largest ratio in Table 2.

A pilot plant was then constructed at Geneseo station for a study of the effects of deaeration with natural gas under actual operating conditions. Five contacting columns, 4 in. in diameter by 20 ft. long, were erected so that five tests could be conducted simultaneously. Each column was packed with stoneware saddle packing. The flow of water and gas was countercurrent through the columns. Steel test coupons were placed inside glass cylinders and the water was caused to flow through these cylinders. The test coupons and glass cylinders were constructed so that the velocity of the water flowing across the test coupon would be approximately the same as that of the water flowing through the main engine piston water service rods, which are the points of most severe corrosion in the system. After the gasified water passed over a test coupon, the water was treated with sodium sulphite for the purpose of removing any trace of oxygen that might not have been removed by the deaerating column. After a suitable retention period, so that the sulphite would have time to react with any dissolved oxygen, the water was passed over another test coupon. The entire series of pilot plant tests was continued for a period



Rear view of vertical twin cylinder engine which drives 35 kw. generator. Note hydraulic relay governor.

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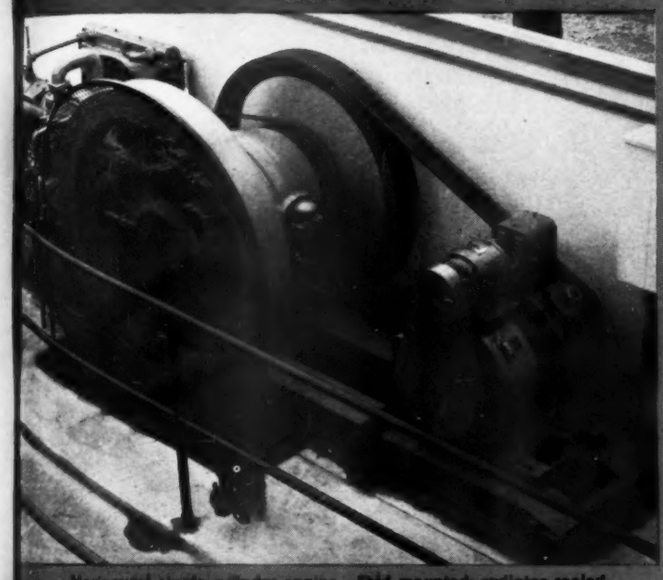
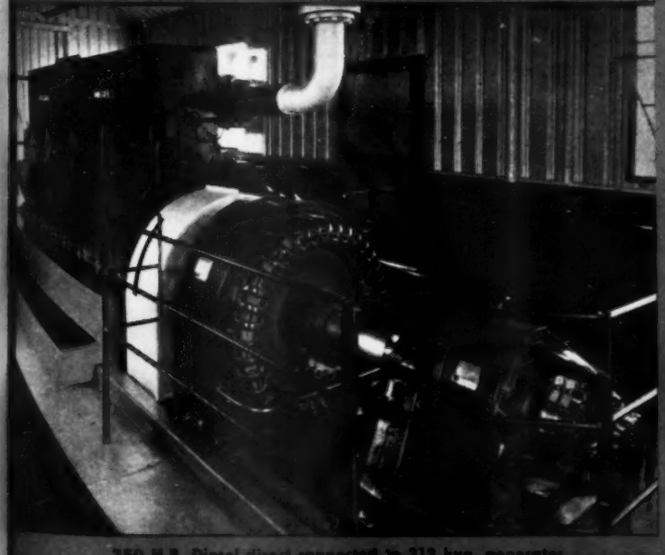


Horizontal single cylinder engine. Skid mounted; radiator cooled. In Illinois. 40 kw. generator.



350 H.P. Diesel direct connected to 312 kva. generator. In North Texas field.

Horizontal twin cylinder engine. In Texas Gulf Coast field. 125 kw. generator.

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TABLE 5

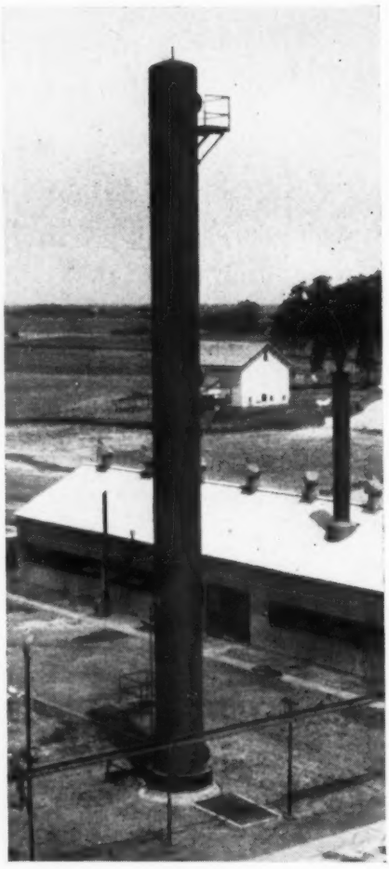
Description of test coupons at end of pilot plant tests

Source and treatment of water supply	Loss in wt., milligrams per sq. in.	Appearance after removing products of corrosion
System water, aerated	206	Etched and pitted over entire area
System water, gasified	2	O. K.
System water, gasified and sulphite treated	4	O. K.
Zeolite treated, aerated	497	Bad cavitation, etching and pitting
Zeolite treated, gasified	6	O. K.
Zeolite treated, direct from softener	331	Etched uniformly over most of area
Zeolite treated, gasified and sulphite treated	13	O. K.
Raw well water, gasified	21	O. K.
Raw well water, gasified and sulphite treated	26	O. K.
Raw well water, direct from well	420	Bad cavitation, pitting and etching
Raw well water, aerated	90	Scattered pits, rather deep and large in area

of 42 days. Results of the tests are summarized in Tables 4 and 5. The data show that the gasified water, in every case, diminished the amount of corrosion to a negligible quantity. It is also indicated that the use of sodium sulphite is unnecessary as an after treatment of the gasified water.

Commercial Unit

In view of the favorable results that were obtained by the pilot tests, it was decided to construct a commercial unit. The design of such a unit might be patterned after any standard contacting tower such as a bubble tray tower or a packed tower. The requirements of such a tower at Geneseo station, however, seemed to be fulfilled satisfactorily from the standpoint of cost and utility, by a somewhat different arrangement. (Fig. 1). The inlet water is discharged near the top of the tower. Approximately 50 percent of the natural gas is injected with the inlet water for the purpose of acting as a gas lift. This feature permits the use of the regular pumping equipment and at the same time causes the inlet water to be lifted to a greater height than could be obtained with the regular pumping equipment alone. Partial deaeration no doubt occurs in the gas-lift column. The rest of the gas is introduced lower down the tower, being broken-up and diffused as tiny bubbles by percolation through a cluster of porous alundum tubes. The 2-in. gas inlet to the porous tubes is connected to a horizontal header (inside the tower), which in turn has 9 laterals extending over the entire cross-sectional area of the tower. There are forty-six 2-in. I.D. by 12-in. long, ½-in. wall alundum tube risers connected to the 2-in. laterals.



Deaerating tower

The space below the alundum tubes in the tower allows the gas bubbles to separate from the water before it is discharged from the base of the tower. The upward passage of the tiny gas bubbles through the tower completes the deaeration of the water and the outlet gas is piped to the fuel header of the main engines. The deaerated water flows through the engine jacket cooling system, thence to the hot well reservoir from which it is pumped over the cooling tower where it again becomes aerated and finally it returns to the deaerating column.

TABLE 6

Sludge and scale analyses

	Engine jacket hard scale wt., percent	Sludge from gasified water wt., percent
Silica	10.31	32.45
Iron and aluminum oxides	2.48	16.48
Sodium chloride	1.65	1.09
Calcium sulphate	8.16	0.49
Calcium carbonate	31.04	11.09
Magnesium carbonate	.....	25.55
Magnesium oxide	28.9	.....
Sulphides as H_2S	.....	0.49
Moisture	2.83	.....
Organic and volatile (by difference)	14.63	12.36
	100.00	100.00

The deaerating column was placed in operation in November, 1939. Several inspections of the engine jackets, at available points, show that the deaerated water has definitely decreased the amount of corrosion. For an additional check on the performance of the deaerating column, a number of steel test specimens were inserted in various parts of the system for a period of four months. A comparison of the loss in weight of the specimen at the water inlet and outlet of the deaerating column indicated that the amount of corrosion had decreased 67 percent after passing through the deaerating column. The results obtained by the pilot plant tests lead to the expectation that even better results can be obtained with the commercial unit when the effect of all variable conditions has been properly evaluated so that optimum operating conditions can be maintained.

An interesting phenomenon was observed during the pilot plant tests as well as during the commercial operation of the deaerator. The system water is normally quite turbid, due to the collection of dust, decayed algae and slime, and other suspended matter. The passage of gas through this turbid water apparently causes the finely divided suspended matter to coalesce. At any rate a definite clarification of the water occurs by sedimentation. The material settles out of the system water as a soft sludge that is easily removed by washing out with a hose. In Table 6, the composition of this sludge is compared with a hard scale that is found on the engine jacket walls.

Laboratory experiments indicate that some sedimentation will occur when finely divided bubbles of air or natural gas are passed through turbid waters. In Table 7, the turbidity of the station No. 1 water was due to a heavy chlorination treatment that caused the decomposition of large quantities of algae and slime and thus imparted a very milky appearance to the water. The station No. 2 water was taken soon after a heavy dust storm and the resulting system water was a deep brown color. Although the character of the suspended matter in both samples was quite different, some sedimentation occurred in both cases.

TABLE 7

Laboratory sedimentation tests

	Turbidity—parts per million	
	Station 1 system water	Station 2 system water
Sample as taken	250	190
Eight hours settling	230	75
4 hr. gasification and 4 hr. settling	190	60
4 hr. aeration and 4 hr. settling	190	65

Upper part of stabilizer; condensers and regulator

All-radiant, direct-fired, vertical-type still

P 773.2

Construction and Operating Features of Gasoline Production Corporation's Cycling Plant

PETROLEUM ENGINEER EXCLUSIVE FEATURE

Absorption unit operates at pressures of 1900-2000 lb., returning stripped gas to producing zone at pressure of 2340 lb.

By GEORGE M. KIRKWOOD

Plant Superintendent, Gasoline Production Corporation

THE Grapeland Cycling Plant of the Gasoline Production Corporation, situated near Grapeland, Texas, is designed to operate at a processing pressure of 2000 lb. per sq. in., stripping the gas and returning it to the producing horizon. The plant has a capacity of 60,000,000 cu. ft. per day.

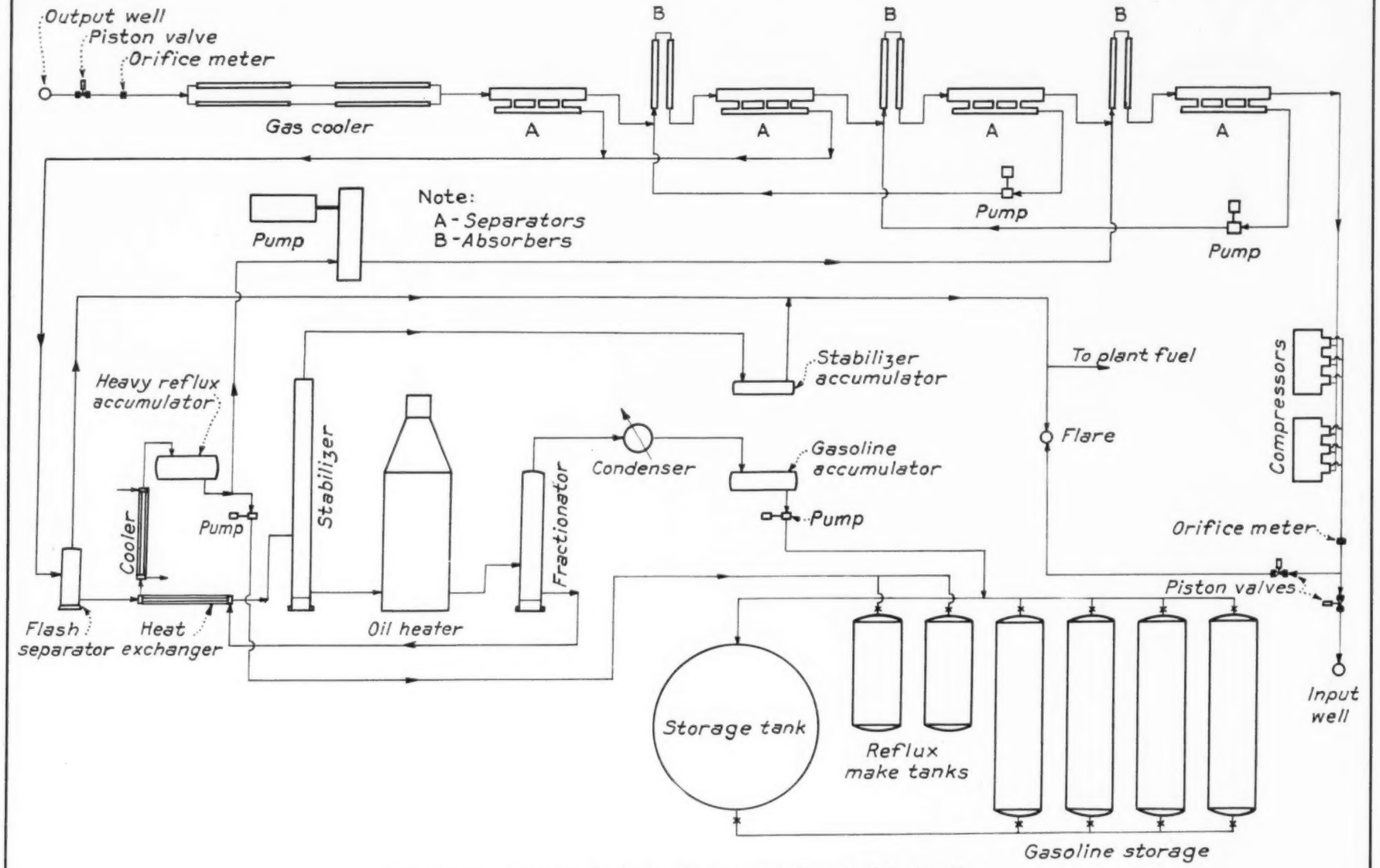
Gas supply is purchased from the Grapeland Oil Company, four producing wells, representing approximately 1300 unitized acres, being at present connected to the plant. These wells are drilled to the 5900-ft. zone, which is the Woodbine sand in the Grapeland area.

Shut-in wellhead pressure is 2225 lb. Output wells are allowed to float on the line with only sufficient choking being made at the wellhead to adjust for equitable volume of withdrawal from each well. Flowing wellhead pressures are in excess of 2000 lb.

Upon arrival at the plant the gas passes through high-pressure water-gas exchangers then through a separator that collects the water and distillate that has condensed as a result of the temperature and pressure changes from bottom-hole conditions to 1950 lb. and 85°F. and sends them to a flash separator. The gas then enters what is termed the "high-pressure unit," which consists of a series of three absorbers and three separators operated at a pressure of 1900 lb. Contact of gas with absorption oil is in three steps. The absorbers are small-diameter vertical units 15 ft. in height and the separators are horizontal units 20 ft. in length. Pressure loss from wellhead to compressor suction is due to friction of flow only; on rates of flow below 60,000,000 cu. ft. per day the plant has operated with pressures as high as

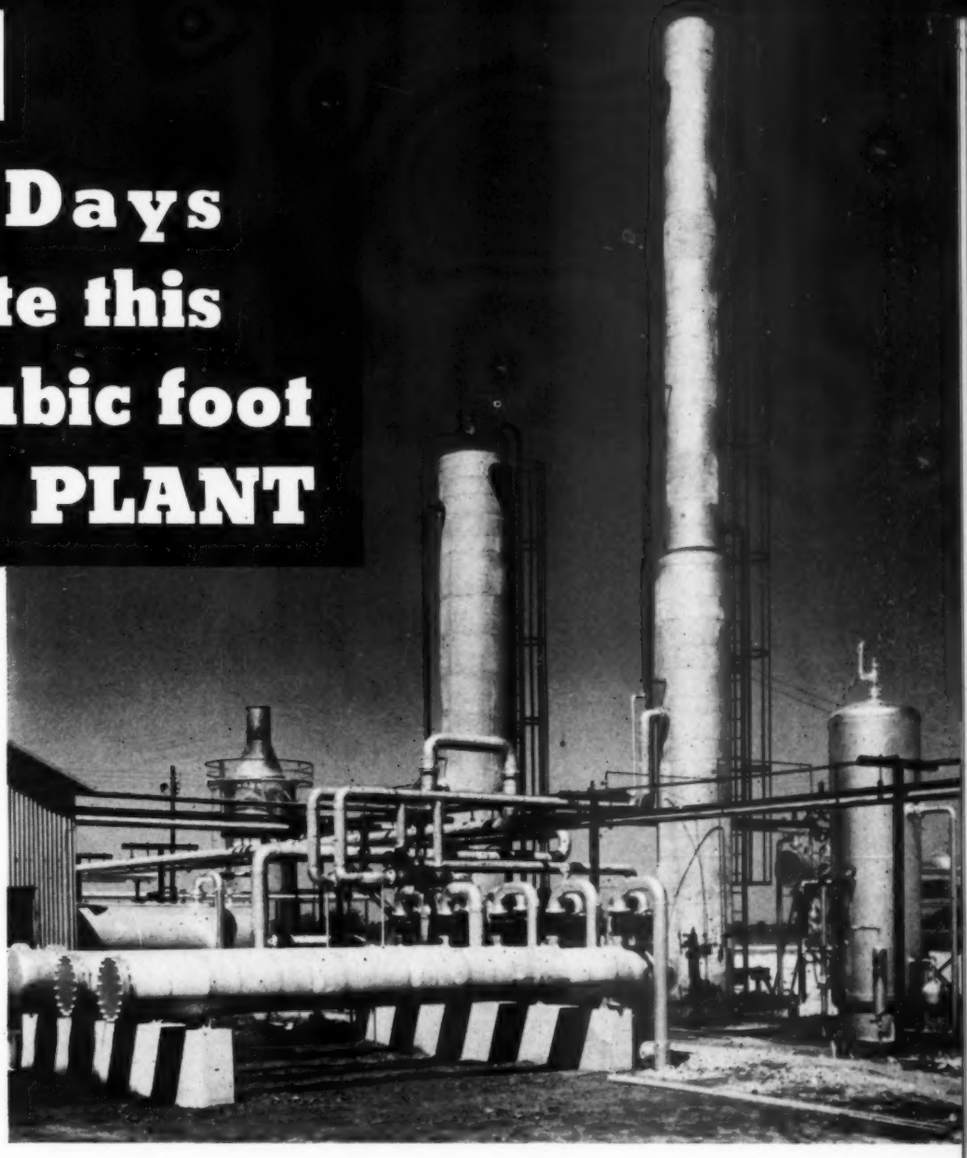
GEORGE M. KIRKWOOD

for eight years was with Midwest Refining Company and Stanolind Oil and Gas Company—In 1930, joined staff of Marland Oil Company as production engineer, and after one year became production superintendent in North Texas for Saxet Oil Company—Occupied that post for three years, then, for a like period, was salesman for Gas-Lift Corporation—Immediately prior to joining Gasoline Production Corporation in March he had for three years been superintendent at Corpus Christi, Texas, for the Process Oil Company.



Flow diagram of Gasoline Production Corporation's Grapeland Cycling Plant

Only 85 Days to Complete this 60,000,000 cubic foot RECYCLING PLANT



ON May 10, 1940, clearing of site was started for the Gasoline Production Corporation's Recycling plant near Grapeland, Texas. On August 3, only 85 days after construction was started, the plant was in operation.

FEATURES OF PLANT

1. Type

High pressure condensation and absorption type as covered by Eureka Process Patents.

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60,000,000 cubic feet per day. Gas is processed at 1900 pounds per square inch and returned to the formation at 2375 pounds per square inch.

3. Compressors

Only 950 horsepower of compressors are required for this 60,000,000 cubic foot plant.

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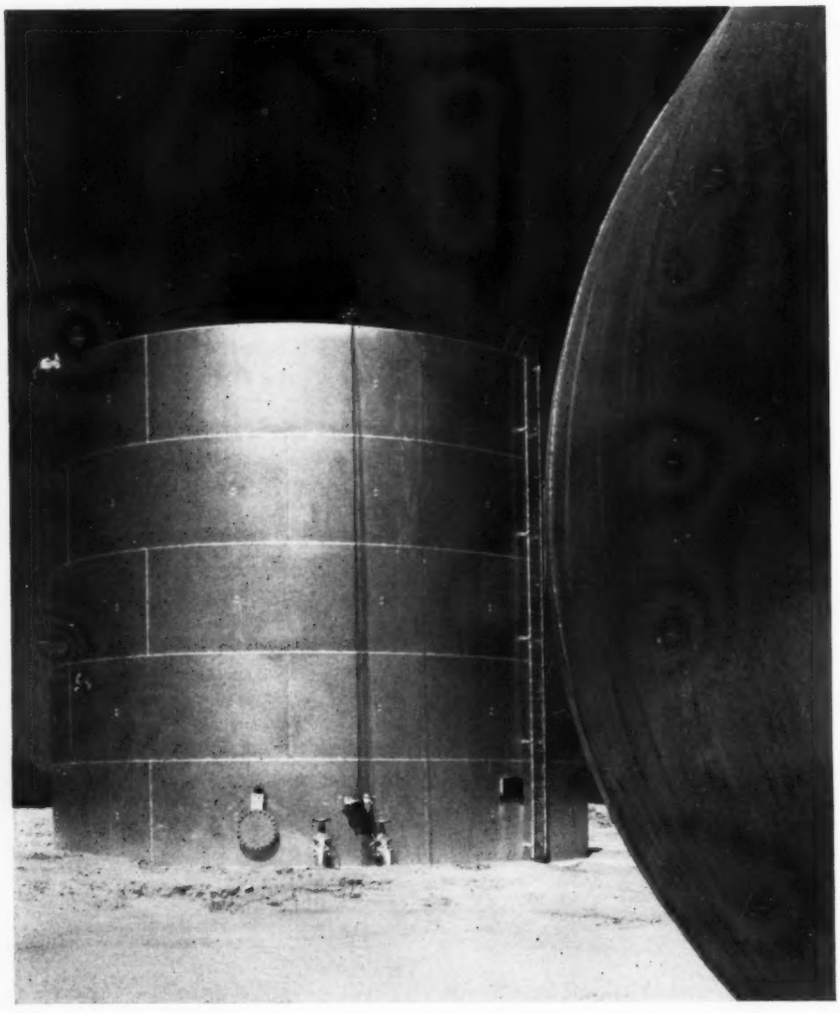


Two of the plants stock tanks

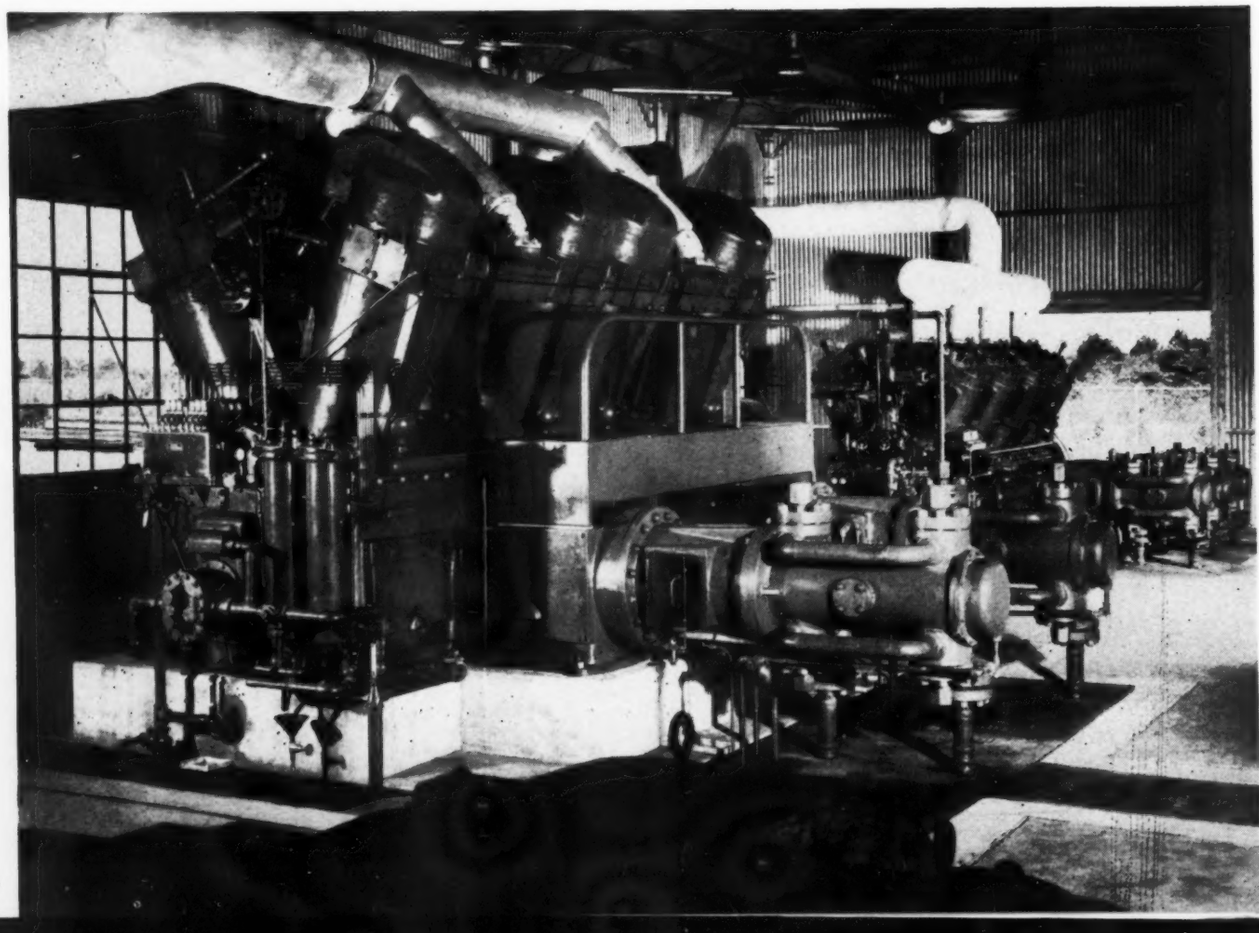
2000 lb. delivered to the compressor suction.

The stripped gas is delivered to the suction of the two compressors at a pressure of 1850 lb. and is discharged at a pressure of 2375 lb. Injection through two input wells to the producing zone is made at a pressure of 2340 lb., there being a 35-lb. line loss between plant and well heads.

Rich oil from the final absorber is sent to a 4-ft. by 13-ft. flash tank where it joins the distillate that was eliminated from the gas in the first separator. Water is drawn-off through an automatic control and a part of the solution gas is liberated in this flash tank. The rich oil is discharged through heat exchangers to the still and is heated to the desired temperature. The still is an all-radiant, direct-fired, vertical-type unit. It is 12 ft. in dia. by 26 ft. high and contains forty-eight 4-in. vertical tubes, each 24 ft. 7 in. in length.

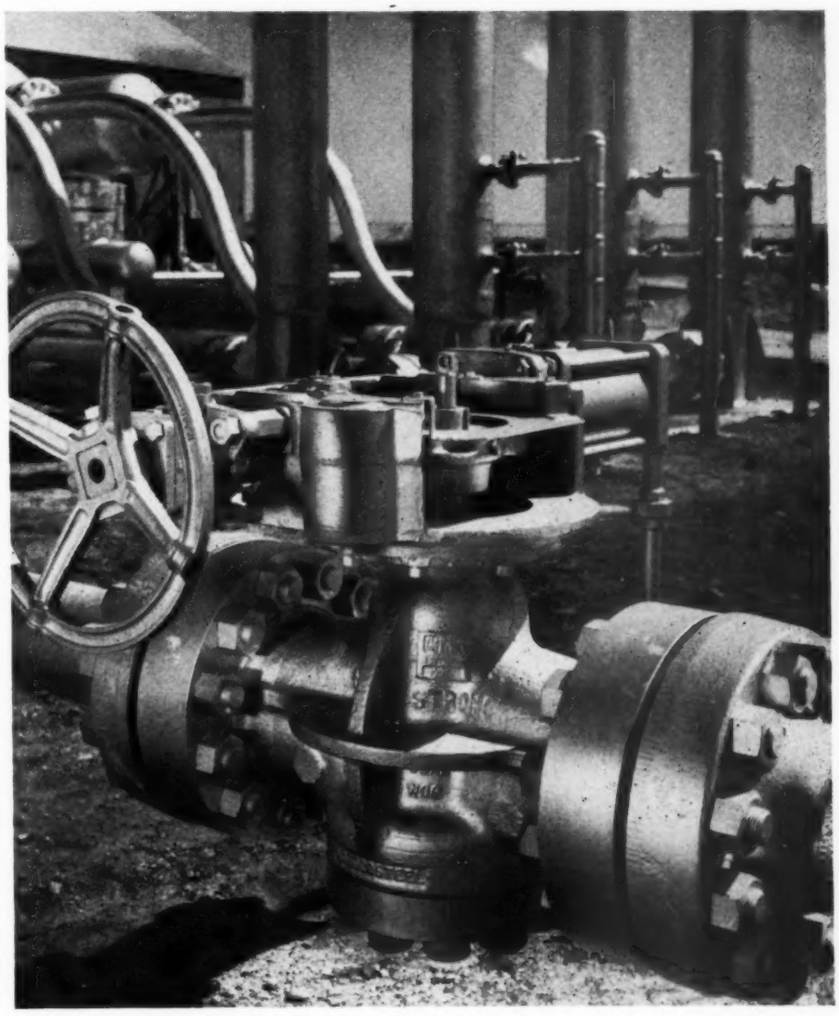
Passing next to the fractionating column, a 385-endpoint motor fuel is taken off overhead. Gas oil is taken from the bottom of the fractionator, and amounts to about 5 percent of the plant's total output. Incidentally, this gas oil is used in the plant as absorption oil.

Three grades of motor fuel are being



Compressors consist of one 650-hp. and one 300-hp. units

Shutdown valve on incoming gas line



manufactured. One is a Q grade gasoline of 74-76 octane number, one an Ethyl gasoline of 80-82 octane number, and the third an unleaded 64-66 octane product.

Tankage, other than that used on the water system and for boiler feedwater, consists of four 500-bbl. and two 250-bbl. horizontal run tanks and two 500-bbl. vertical tanks for gas oil storage. In addition, there is a 5000-bbl. tank that serves for lead blending, and three 5000-bbl. tanks at the loading rack. Of the latter, one is for each of the three grades of gasoline. The finished gasoline is pumped to the loading rack, which is 2 miles east of the plant, through a 3-in. line and by a reciprocating or a turbine-driven pump or both.

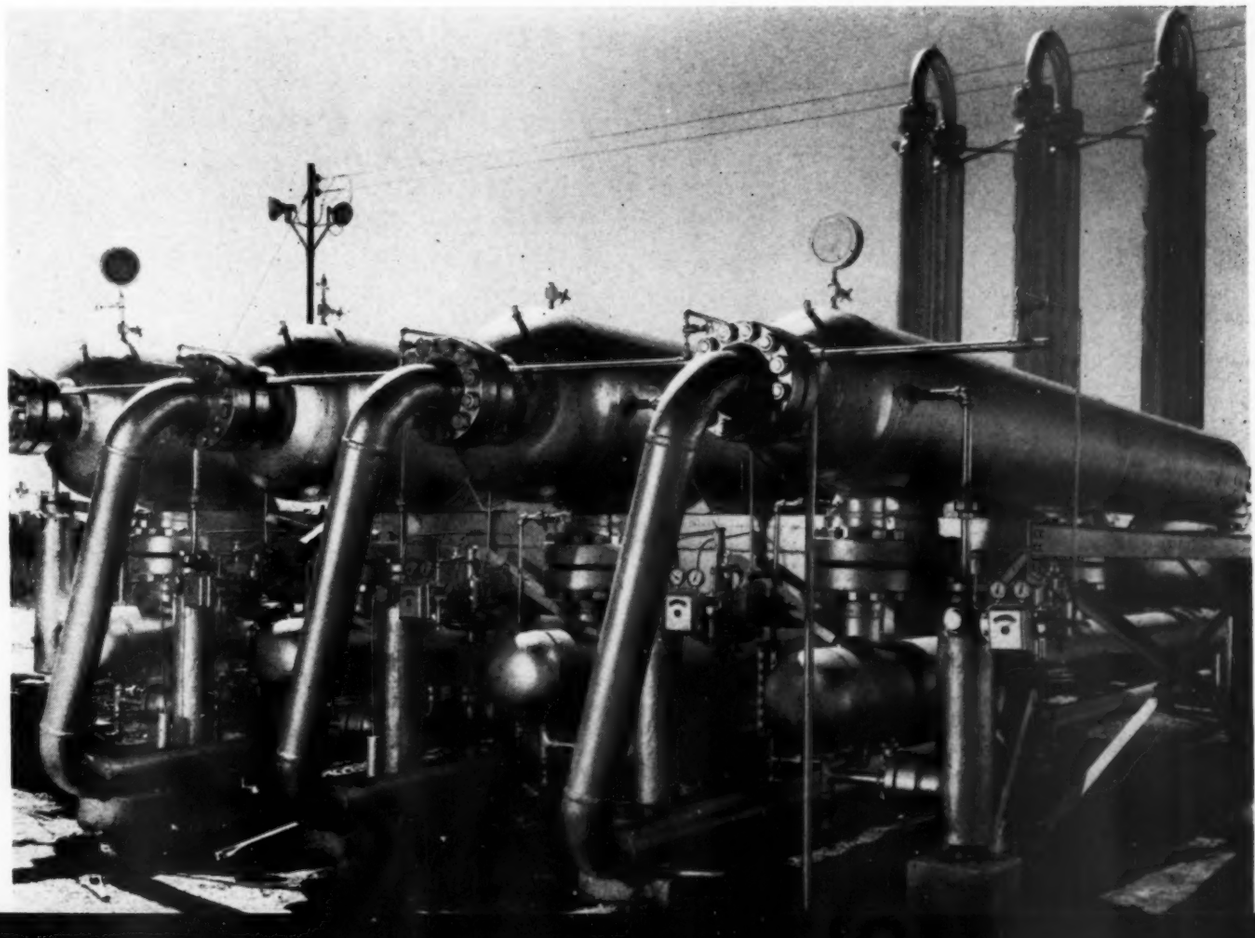
Lean oil coming off the bottom of the fractionating column is cooled and discharged to the lean oil supply tank, a 5-ft. by 14-ft. vessel having a capacity of 50 bbl. The high-pressure absorption oil pumping unit consists of a plunger-type pump driven by a 300-hp., 2-cycle gas engine.

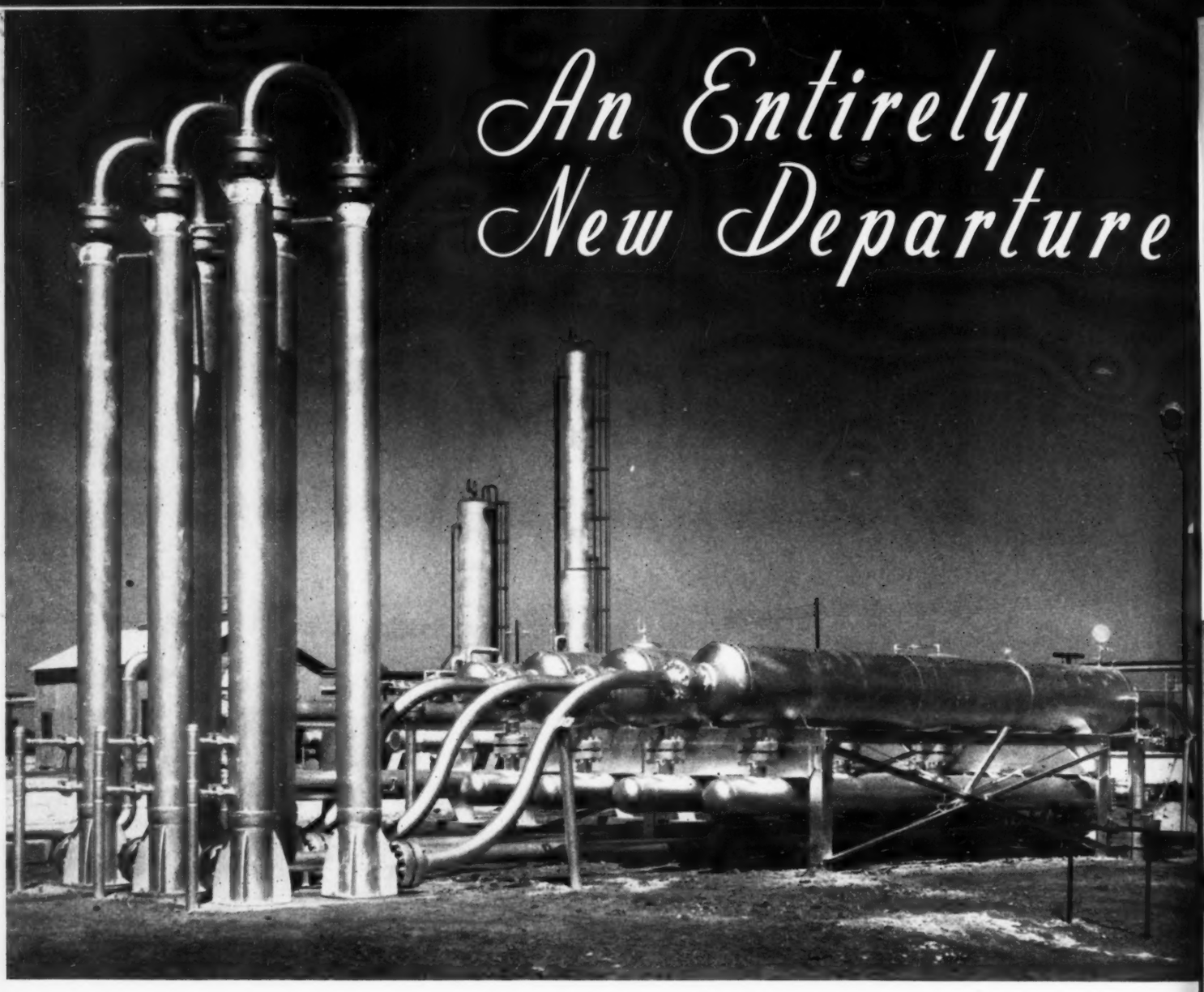
Compressors

Compressors consist of one unit of 650-hp. at 300 r.p.m. and one of 300-

(*Continued on Page 58*)

Separators (foreground) and densifiers (background)





An Entirely New Departure

NATIONAL introduces an entirely new departure in distillate separator design. This innovation, shown herewith, constitutes a departure from the customary vertical separator design to horizontal design separators. The results have been phenomenal, making possible the efficient and economical extraction of distillate from 58 million cu. ft./day of gas through the last separator at exceedingly high pressures.

By extracting at pressures above 1950 psi., the horsepower required for gas cycling to this high pressure formation was greatly reduced. Other economies were made by reduction of space due to compact design and with low initial and maintenance cost. This system is daily handling 58 million cubic feet of gas entering at 135° to final extraction temperatures above 110°F. Attained extraction of pentanes and heavier—96% and better. Propane and butane may also be recovered in desired quantities.

National is thoroughly equipped to recommend, design, and install these and other types of pressure vessels up to 4000 lbs. working pressure and higher. Construction furnished to any code specification, including fully X-Rayed Class I construction.

The complete extraction system shown was fabricated, set up, and assembly tested at 1½ times its designed 2000 lbs. working pressure in our shop, and dismantled and sent to location for installation. Consult National for your high pressure vessel requirements as well as storage for same.

It's a National

Absorption and Separation Process

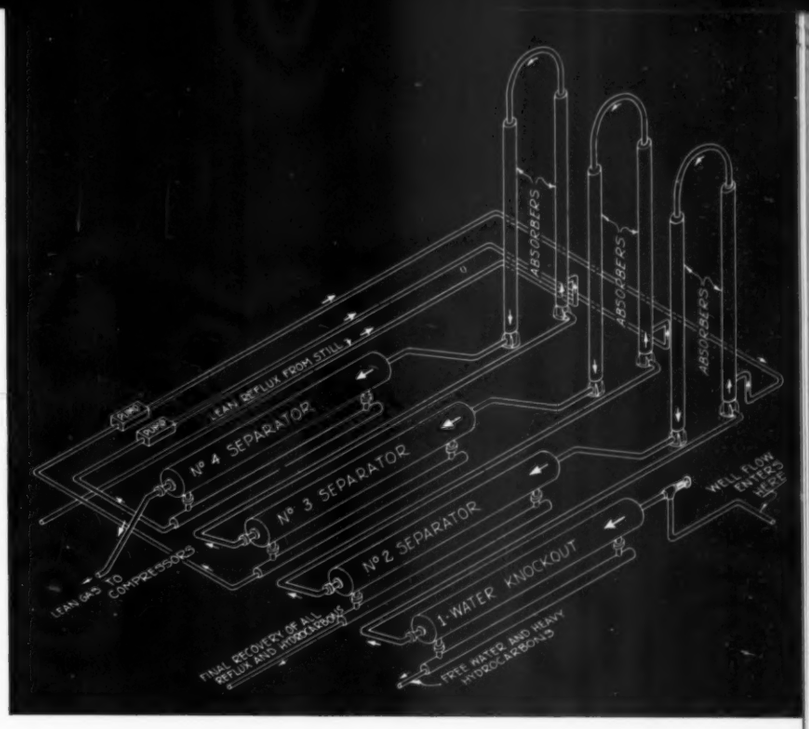
3 Stage Contact

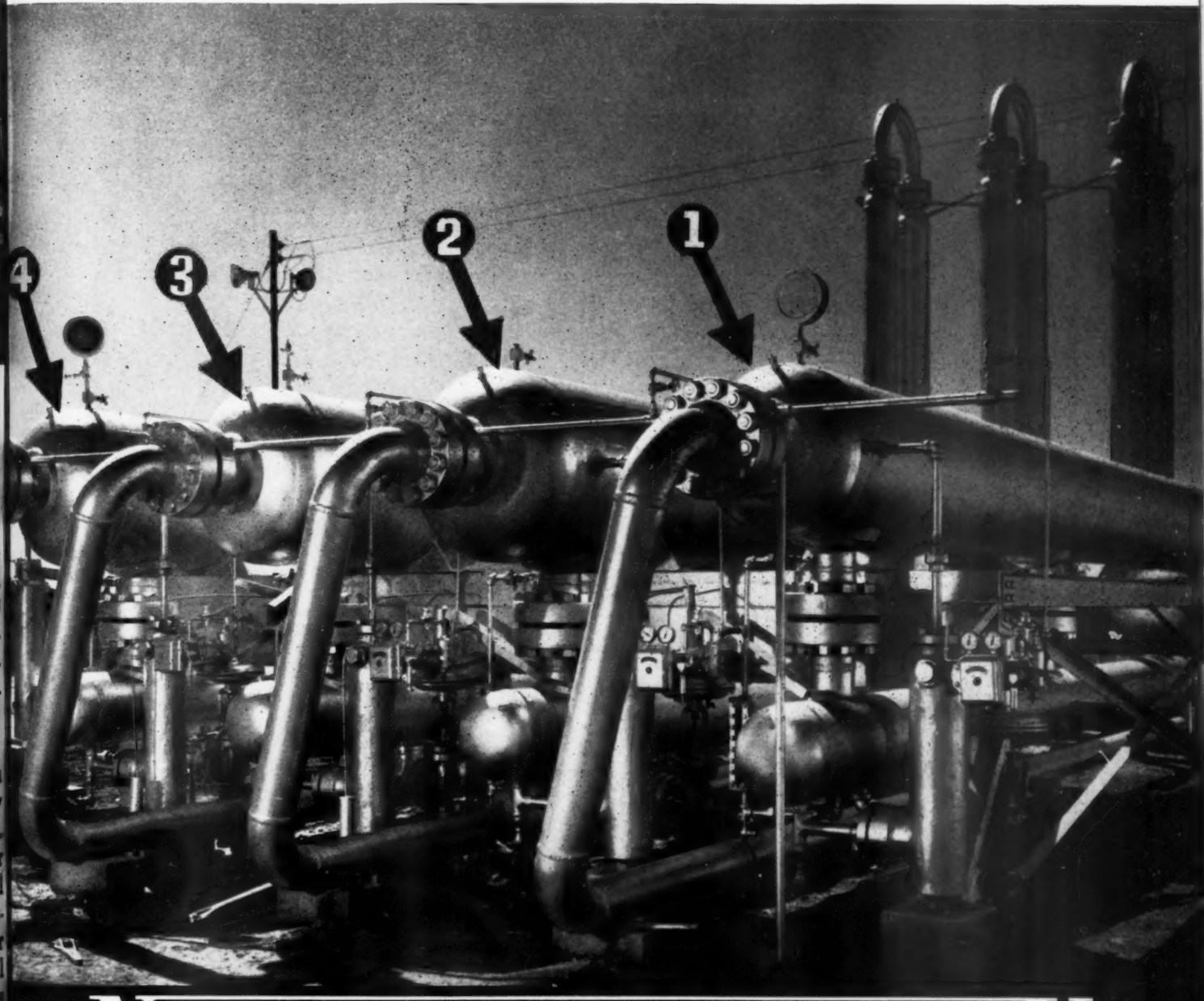
No. 1 Water Knockout Vessel. Well flow enters this vessel where condensed hydrocarbons and condensed free water is separated from flow stream.

No. 2 Separator. Extracts hydrocarbons and reflux from first series of absorbers. Absorption medium introduced into flow stream at first absorber tower.

No. 3 Separator. Extracts additional hydrocarbons and all reflux from second series of absorbers.

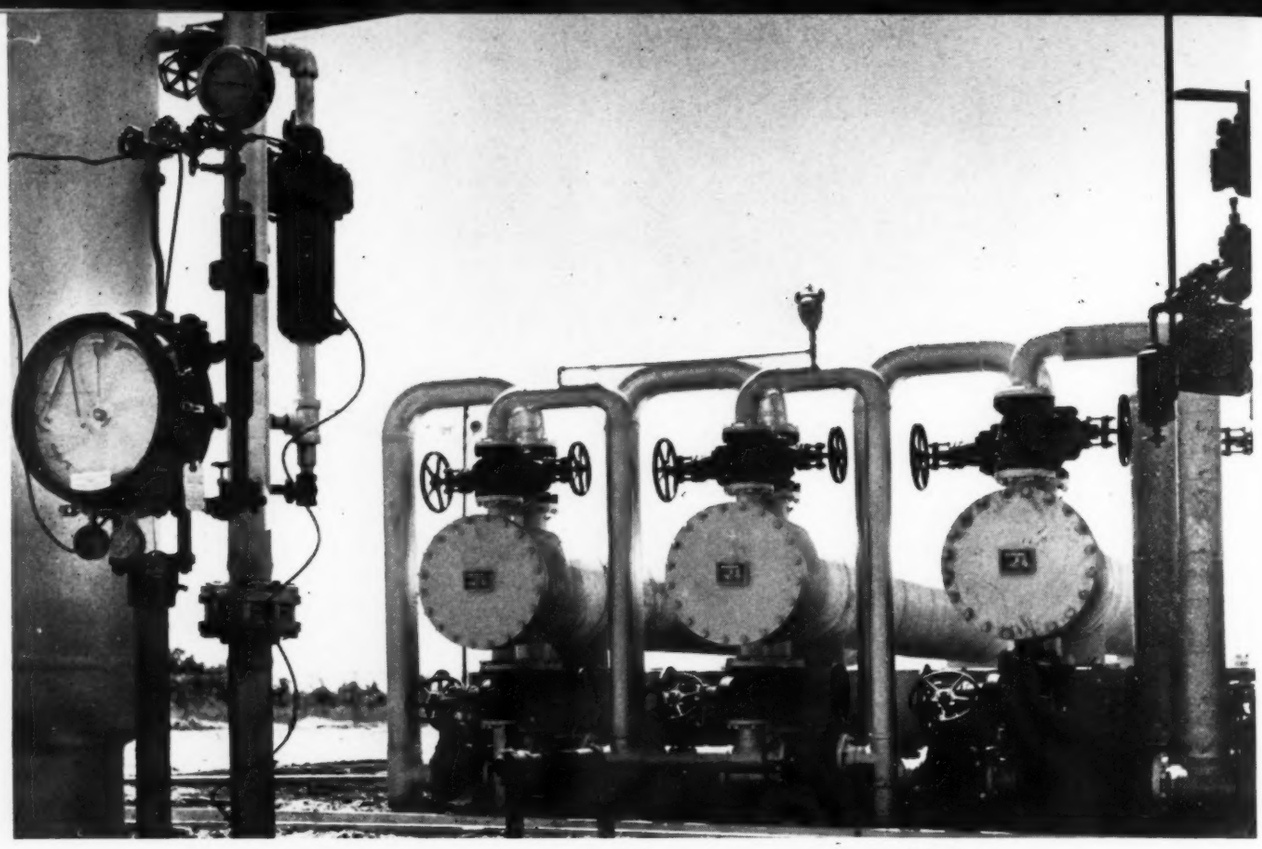
No. 4 Separator. Final separation of all gas of flow stream. Remainder of liquefiable hydrocarbons removed herein and dry gas stream passed out of separator to compressors at pressures above 1900 psi.





NATIONAL TANK COMPANY

TULSA, OKLAHOMA.



Heat exchangers and gas coolers. To the left, metering equipment on flash separator

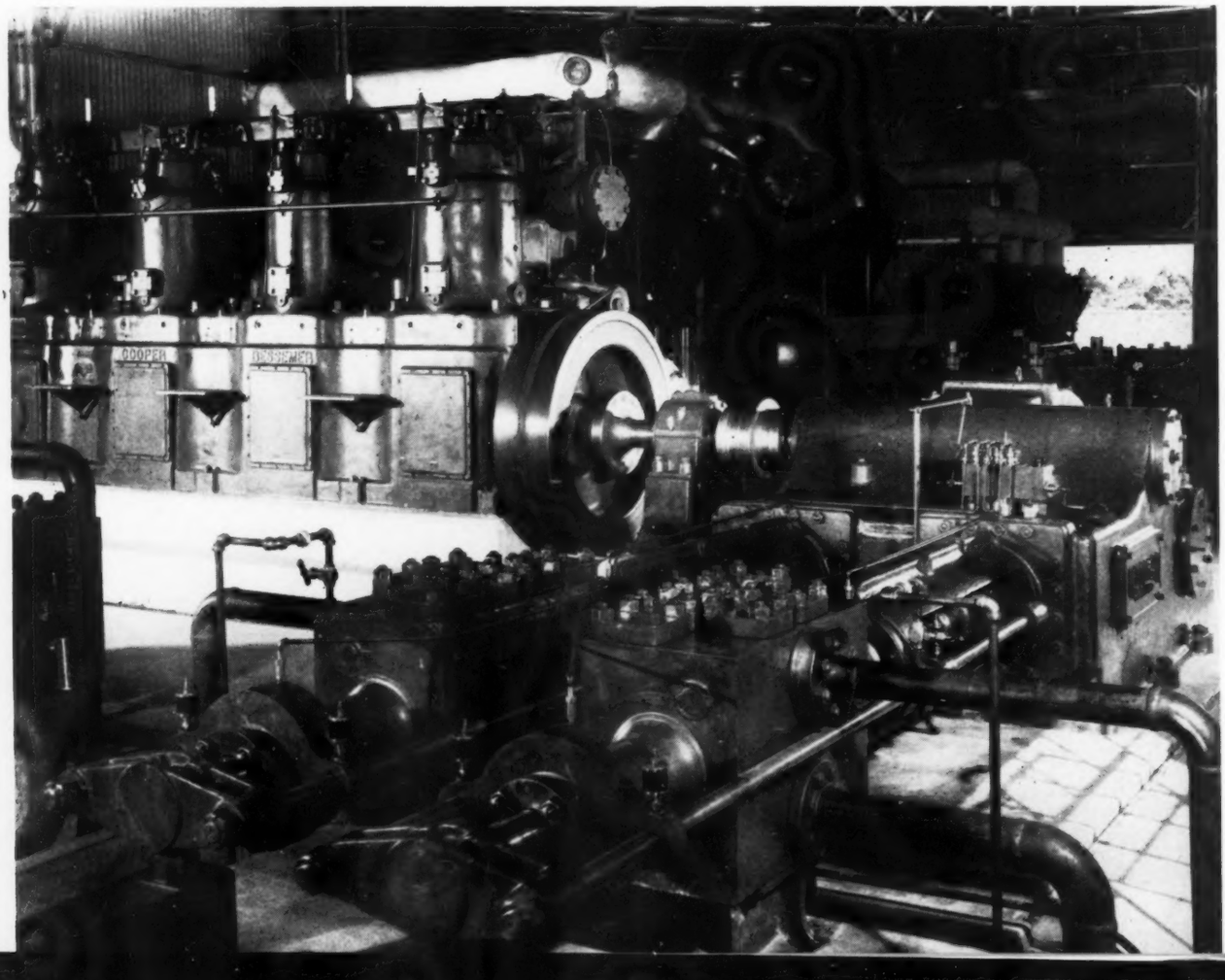
(*Continued from Page 55*)

hp. at 350 r.p.m. The former has two compressor cylinders of 5¼-in. bore and 15-in. stroke and the latter, three 3-1/16-in. by 12-in. compressor cylinders.

Both compressors consist of a V-type, 4-cycle, single-acting gas engine and a horizontal crosshead-type compressor built into a single, heavy-duty unit.

Power cylinders on the 650-hp. unit have alloy-cast-iron liners and are fitted with detonation-quieting heads. The water joints at the top and bottom of the liners are sealed with synthetic rubber rings and the bottom joint has a water trap and tell-tale

High-pressure absorption oil pumping unit—300-hp. gas engine driving plunger-type pump



connection to prevent leakage of water into the crankcase. Cylinder heads are of the valve-in-head type having one-piece silchrome inlet and exhaust valves.

Power cylinders on the 300-hp. engine are of the non-liner type. One-piece silchrome valves are also used in this engine.

Power pistons are of alloy-cast-iron and are fittted with 4 compression rings and 2 oil-control rings. Piston pins are full floating, running in replaceable bronze bushings. The large engine has oil-cooled pistons.

Full force-feed lubrication is provided. A spiral-gear oil pump, direct-connected to the crankshaft, forces lubrication to all main, crank-pin, piston-pin, wrist-pin, crosshead-pin, and camshaft bearings, crosshead shoes, and rocker arms. The same system also sprays governor parts, magneto drive, etc. Oil filtration is continuous. "One-shot" lubrication from a central lubricator is provided for the power valve stems, and a separate force-feed lubricator has individual, adjustable sight-feeds to each compressor cylinder and stuffing box.

The engine jacket water system is completely closed. Each engine has a built-in water pump to maintain high-velocity flow through the cylinder jackets and a water supply tank floats on a common suction line.

Cooling-Water System

The plant cooling-water system is unusual in that no cooling tower is provided and the water is circulated directly from supply tanks through the various cooling equipment to an input water well.

The water supply is obtained from five 400-ft. wells and a nearby creek. A sixth well has been drilled as an injection well, and is situated 2500 ft. from the nearest producing well. Water is lifted to two 200-bbl. tanks from where it is pumped through the various coolers by a turbine-driven centrifugal pump, thence to the water-input well.

Steam Plant

Two 110-hp. boilers provide the steam required for processing and to drive the plant's turbines. Except for a small quantity of makeup, condensed steam provides the necessary boiler feedwater. The 28-bbl. feedwater tank is equipped with an automatic level control that cuts-into the line to the input water well for makeup water.

Electric Generation

Electricity for plant consumption is generated by a 15-kw. generator driven by a steam turbine.

Buildings and Cottages

Plant buildings, other than that housing the offices, laboratory, and warehouse, are of steel truss construction covered with galvanized corrugated iron. A building of frame construction houses the offices, a completely equipped laboratory, and a warehouse.

Eleven cottages have been built as living quarters for the plant's operating staff.

Gathering Lines

A total of 41,000 ft. of gathering and gas-input lines was laid to serve the plant. The gathering system (35,000 ft.) consists of 6-in. main line and 3-, 4-, and 5-in. laterals. Separate input lines are laid to each injection well. These lines are 4 in. and 5 in. in size and each is approximately 3000 ft. long.

Contractors

H. B. Zachry Company of Houston, San Antonio, and Laredo, Texas, was the general contractor in charge of construction. Design was by Foran, Knode, Boatright and Dixon of Houston. Work was begun May 10 and the plant completed August 3.

Designs, Plans and Specifications

for

GASOLINE PRODUCTION CORPORATION'S

GRAPELAND CYCLING PROJECT

by

Foran, Knode, Boatright & Dixon

Consulting Petroleum and Natural Gas Engineers

Second National Bank Building

HOUSTON, TEXAS

Stock tanks (foreground), and water tanks (background)

P 773.
P 771.12

Engineering Design of New Cycling Plant

Recovery from gas phase is by multiple-contact "concurrent" absorption process—High-pressure lines and headers installed in manner to minimize stress deformation

By P. C. DIXON

Foran, Knode, Boatright and Dixon

THE engineering design of a cycling plant properly begins with the output and input wells, their location and completion, and of course the field testing to obtain physical information necessary for valuation and, later, plant design.

In coöperation with the Grapeland Oil Company, well locations for the Gasoline Production Corporation's cycling plant have been made to cycle the reservoir contents most advantageously, and well completions have been fashioned[1] so that, for example, the residue gas is injected into the input wells at pressures of only 115 lb. above original shut-in field pressure.

All high-pressure lines and headers are installed so that stress deformation is minimum under operating conditions. Field lines normally operate at a temperature of approximately 120° F. In order to minimize line movement, headers were bolted in place and field lines tied-in and covered in the heat of the day so that pipe temperatures approached operating temperatures; field lines are laid "tight." In order to prevent stresses on wellhead trees or plant headers in the event of line failure or due to line movement, large reinforced-concrete blocks are used to back-up lines where they

[1] "Condensate Wells — Completion and Recycling operations," by E. V. Foran and P. C. Dixon. A.P.I. *Drilling and Production Practice*, 1939.

P. C. DIXON

received the degree of petroleum engineer from the Colorado School of Mines in 1931, after interrupting his schooling to work one year in 1928 for the Shell Oil Company of California—Served as gas engineer for Public Service Company of Colorado, 1931 to 1936—Served on the faculty of the Colorado School of Mines as assistant professor of petroleum engineering, 1937-1938 — Resigned in August, 1938, to become associated with the firm of Parker, Foran, Knode and Boatright — Since June, 1940, has been a member of the firm of Foran, Knode, Boatright and Dixon.

emerge from the ground at well connections and at plant inlet and discharge. Emergency shutdown equipment is installed on each output well in the form of a flow meter incorporated in the usual well orifice meter so that in the event of line failure the output wells will automatically be closed-in. Input wells are equipped with check valves to prevent backflow of gas.

Recovery from the gas phase is made by the multiple contact "concurrent" absorption process[2] as illustrated in the flow diagram. In this process the absorption oil and the gas, while in contact, flow concurrently; that is, they flow together through a densifier or absorber and into a separator. In the overall, however, the oil travels a path in countercurrent relation to the gas due to its transfer, by pump, from last to first stage of contacting.

This method of processing is no more expensive in first cost than the conventional countercurrent process and has at least two advantages over the conventional method: (1) processing pressure is higher, reducing compressor costs, and (2) the system is extremely flexible, that is to say there is no critical top capacity that ordinarily in a countercurrent tower is a function of temperature, pressure, and gas velocity.

After installation of the high-pressure processing equipment the plant capacity was increased from 45,000,000 cu. ft. per day to 60,000,000 cu. ft. per day. Without alteration in any way the "high-pressure unit" is performing as efficiently at the higher gas rate and without any carryover of absorption oil. As an experiment the processing temperature was raised 15° above normal for a period of 48 hours and no carryover was observed at this higher flow rate.

Factors that should be properly evaluated before selection of the type of process for high-pressure recovery include: (a) physical characteristics of the reservoir gas, (b) reservoir pressure, and (c) economics of product manufacture. As all present methods of processing have their proper application, it is advantageous to apply the one best suited to the individual field. In this instance the concurrent absorption method was selected as best suited to the conditions.

Compressors and high-pressure oil pumps are housed separately and so arranged that all units are well-lighted and accessible for maintenance. All lines and equipment operating at high pressure are confined to one end of the yard area immediately adjacent to the building containing the pumps and engines.

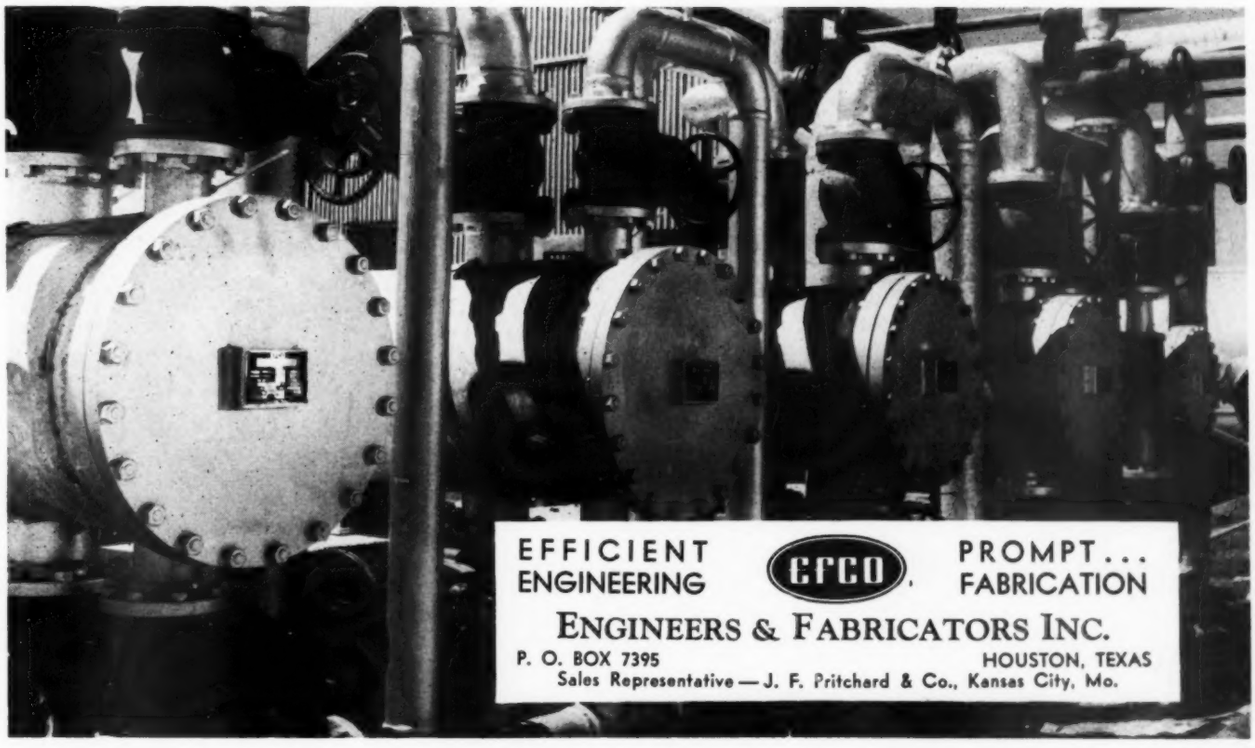
The boilers and direct-fired still are situated across the prevailing wind at the opposite end of the plant yard, with the customary low-pressure fractionating and processing units spaced evenly between the two hazardous zones.

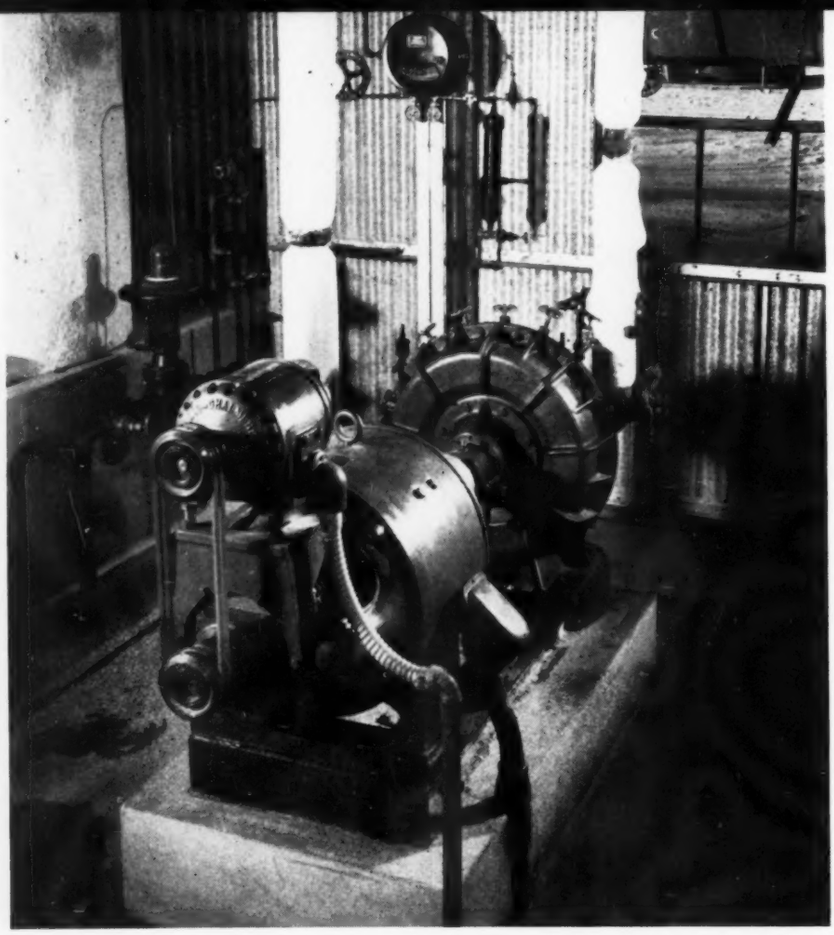
The Ethyl lead-blending plant is situated at the main plant site rather than at the loading rack to consolidate and simplify overall plant operations and to provide adequate utility service in the event of emergencies. The blending plant is drum-to-weigh-tank with a steam-turbine-driven centrifugal blending pump.

Plant operations have been simplified and automatically controlled to relieve operators of many routine

[2]Methods of high-pressure processing and method of conserving reservoir pressure (gas injection) licensed by Depco.

ANOTHER CFCO INSTALLATION: GASOLINE PRODUCTION CORP.





Electricity is provided by a 15-kw. generator driven by a steam turbine

tasks. All lines and equipment have been arranged to facilitate ordinary inspection and maintenance; utility has been stressed rather than appearance, although the completed plant is pleasing in appearance by virtue of its simplicity.

Principal Equipment

Major items of equipment, including the names of manufacturers, follow:

Insulation—Alfal Insulation Company, Inc.

Electric generator—Allis-Chalmers Manufacturing Company.

Gas-engine piston rings — American Hammered Piston Ring Division of Koppers Company.

Pipe—Bethlehem Steel Company.

Safety heads — Black, Sivalls and Bryson, Inc.

Boiler feedwater level controller — J. A. Campbell Company.

Relief valves and gauges on gas coolers—Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore, Inc.

Compressor piston rod packing and compressor piston rings—C. Lee Cook Manufacturing Company.

Gas engine driving high-pressure absorption oil pump—Cooper-Bessemer Corporation.

Steam turbines—Coppus Steam Turbine Co.

Valves and fittings—Crane Company.

Laboratory equipment—W. H. Curtin and Company, Inc.

Orifice fittings—Daniel Orifice Fitting Co.

Steam turbines—Elliott Company.

Heat exchangers, gas coolers, condensers, sub-coolers—Engineers and Fabricators, Inc.

Control equipment—Fisher Governor Co.

Boiler burners—Forney Engineering Co.

Control equipment and meters—Foxboro Co.

Gas compressor units—Ingersoll-Rand Co.

Reflex gauges — Jerguson Gage and Valve Company.

Plug valves—Merco Nordstrom Valve Company.

Densifiers (absorbers), separators, tanks, and loading rack—National Tank Company.

Fuel oil pump—National Transit Pump and Machine Company.

Boilers—Oil Well Supply Company.

Still—Petro-Chem Development Company.

Steel buildings—Star Manufacturing Co.

High-pressure fittings — Taylor Forge and Pipe Works.

Fire protection equipment—Technical Products, Inc.

Stabilizer and fractionator—Tulsa Boiler and Machinery Company.

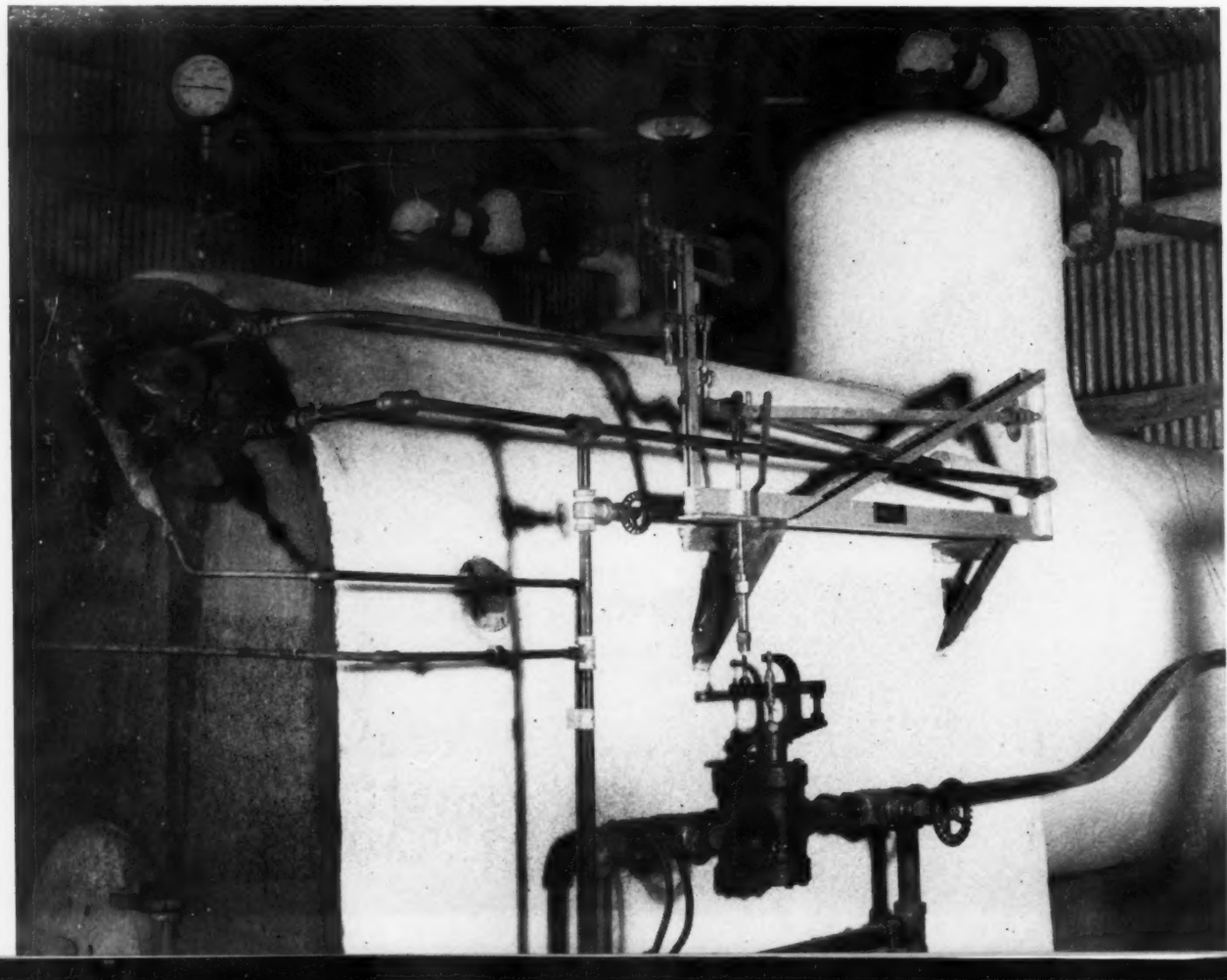
Pumps—Union Steam Pump Sales Co.

Pumps—Worthington Pump and Machinery Corporation.

Tanks and shell for still—Wyatt Metal and Boiler Works.

Still burners—John Zink Company.

Two 110-hp. boilers are used to generate steam



Of Course . . . . . .
John Zink HBM* burners are used in this Petro-Chem furnace and John Zink VBM burners are used in the Lone Star Gasoline Plant boilers.
* The burners fire tangentially into a recessed refractory floor designed: to complete combustion rapidly; prevent flame impingment; and produce swirling flame pattern.
JOHN ZINK COMPANY TULSA, OKLAHOMA

Methods of Fastening Dead-End of Wire Rope Drilling Lines

PETROLEUM ENGINEER EXCLUSIVE FEATURE

Modern practice of pulling-through and cutting-off long lines demands that improved methods of dead-end fastening be adopted

By H. LEE FLOOD
Associate Editor

THE ENTIRE SUBJECT of wire line usage in drilling practice covers a wide field. Though there are many important phases of the subject that might be profitably discussed, the present article will be confined to a practical consideration of the methods being used to fasten the ends of drilling lines on rotary drilling rigs. To avoid the risk of becoming tedious, there will be no effort to present an exhaustive, tiresome treatise in which every detail is given of the many wrong practices being followed. Neither is it believed practicable to discuss every variation that is employed in applying what have come to be recognized as the better methods of fastening the cable ends—both on the drum and at the dead end. Instead of this, the general objectives sought will be stressed, citing only a few of the specific methods by which these objectives are being attained by the more progressive drilling companies.

The method of fastening the dead end of a drilling line has assumed major importance in modern wire-rope practice. This is because of the trend during recent years to the use of longer lengths of drilling line than are actually in service at a given instant, thus permitting the line to be pulled through and "cut-off" so that the points of wear will be better distributed and greater "per ft." service from the wire rope will be obtained.

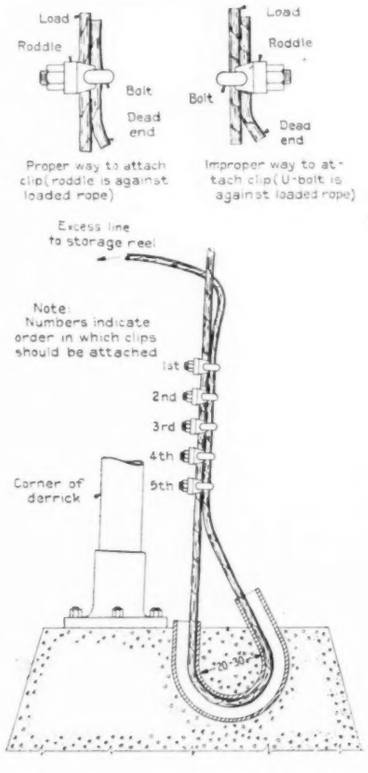
Although this practice of purchasing long lines and cutting-off is not universal by any means, the economies of this method are so obvious that, in the present discussion, it will be assumed that long lines are being used. It is possible in a 136-ft. derrick, with 6 lines strung, to use a 1250-ft. length of wire rope but this is just about the minimum. Although this length line is purchased by some contractors, it affords no provision for cutting-off and, consequently when the line becomes badly worn at the points of severest wear, the entire line must be discarded. It is possible, of course, to change ends either by picking up the crown block and reversing it or by re-stringing the line. This reversal of ends adds materially to the service obtained from a given line but, without the extra length needed for cutting off, there will be substantial portions of the entire length of line that never receive their proportionate share of the wear.

In stringing-up a new long line, the wire rope reel is usually mounted in a fairly substantial manner just outside the derrick near the deadline fastening. The line is strung between the crown and traveling blocks in the desired number of passes and the free end of the line is attached to the drawworks drum and a number of turns are wrapped on the drum before the dead end of the line is made fast and the traveling block is picked up. The usual amount of line wrapped on the drum before the block is picked up varies from about one-quarter to one-half of the drum width. In only a few instances is the older practice still followed of reeling a full layer and three or four wraps of the second layer before the block is picked up. This represents an unnecessary waste of rope.

Long lines, in which there is always an extra amount left on the reel, have made the term "dead end" a misnomer inasmuch as the clips or clamps are now attached a considerable distance from the true end of the line.

It is the fact that the portion of the line on which the clamps or clips are attached will soon become a part of the working line that has caused greater attention to be given to the manner in which the wire rope is treated at this particular point. No longer is it possible to bend, loop, or otherwise damage the wire line at the dead end as in earlier days because now injury at this point may well cause the discard of a considerable section of unused rope.

Fig. 1. U-shaped pipe is embedded in concrete. Right and wrong ways to attach cable clips



Methods of Fastening the "Dead End"

The principal objective in improved methods of fastening the dead end of drilling lines is to observe as much care in avoiding severe reverse bends as in other parts of the rope. Consequently, the same minimum diameters of reverse bends should be adopted as are now recommended for sheaves.

One company on the Gulf Coast is attaining the desired maximum curvature in reversing the direction of the rope by installing a U-shaped pipe through which the line passes. On land locations where concrete may be poured, these curved pipe are embedded in concrete with the base of the U downward and the two open ends of the pipe so fixed that the line from the crown block may enter one end and be pulled out the other and the two ropes clamped together. (Fig. 1.) On barges used in marine drilling the same type of arrangement may be provided.

Another method of fastening the line, improvised and used by several companies involves the use of a cable-tool clamp such as is used below the

temper screw to fasten the drilling line in cable-tool drilling. This method has the advantage of permitting the line to be pulled-through and cut-off more quickly than when the bolts of cable clips must be loosened as in the other methods. Some companies believe that the cable-tool clamp in itself affords adequate anchorage and security against slippage of the rope. Other users of this type of clamp prefer to provide the additional security of an extra clamp above the cable-tool clamp. (Fig. 2.)

A patented device that is favored by some operators is now available that permits several turns of the rope to be wrapped around a spool and then clamped. The diameter of the spool is large enough to avoid sharp turns in the rope. (Fig. 3.)

Applying Cable Clips

Probably the greater number of workmen on drilling rigs know the right and wrong way to attach cable clips. There are enough wrong applications noted in the field, however, to warrant a review of this relatively simple though important point.

The usual wire rope clip consists of a roddle and a U-bolt threaded on both legs. The roddle is grooved to fit the rope and the U-bolt fits through holes in the roddle. The roddle is designed to bear against the wire rope without crushing the wire and consequently this part of the clip should always bear against the live side of the rope, not the dead side, as illustrated in Fig. 1.

The table on this page shows the minimum number of clips that are recommended for ⅞-in. to 1¼-in. diameter lines.[1] The values in the table are based on 6 by 19 plow-steel wire rope and may be interpolated for other types.

Fastenings of wire rope smaller than ¾ in. should have not less than 4 clips. The clips should be inspected daily and the bolts tightened because the bolts become loose as the rope stretches. It is preferable to socket rope larger than 1¼ in.

Several new types of cable clips are now available that are finding favor with some companies. One of these clips consists of two identical halves, each of which serves as a roddle and bolt combined. The chances of injuring the rope are minimized when this clip is used because of the greater area in contact with the rope.

[1]From RR-R-571, *Federal Standard Stock Catalog*, Section IV (Part 5) "Federal Specification for Rope; Wire."

Fig. 2. Conventional cable-tool drilling clamp as dead-end tiedown permits "cut-off" of line to be made quickly

An important point in fastening clips that is often overlooked is the sequence in which the clips are tightened on the rope. The proper way is first to tighten the clip that is farthest from the loop and then successively tighten the other 4 clips. This insures that each clip will carry its portion of the strain. When the clip nearest the loop is tightened first, it carries the load alone and may cause failure.

Fastening the Drum End of the Line

It is no longer necessary to loop and clamp the rope end at the drum. Neither is it necessary to hot-socket the end. A collar is now available that may be quickly slipped over the wire line and bolted in place. Use of this device results in a neater, quicker job.

General

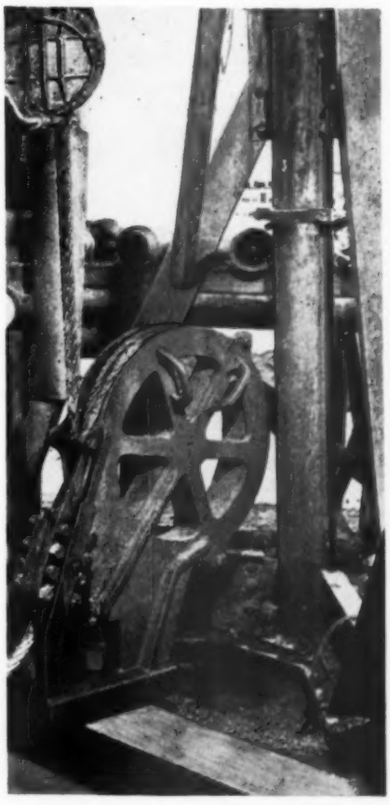
Almost universally, it is now recognized that correct sheave diameters are essential if injury to the wire line is to be avoided. Yet this same reasoning often is not applied in the fastening of the dead end of the rope.

The methods that have been outlined offer a means of attaching the wire line at the ends so that the wire will not be damaged.

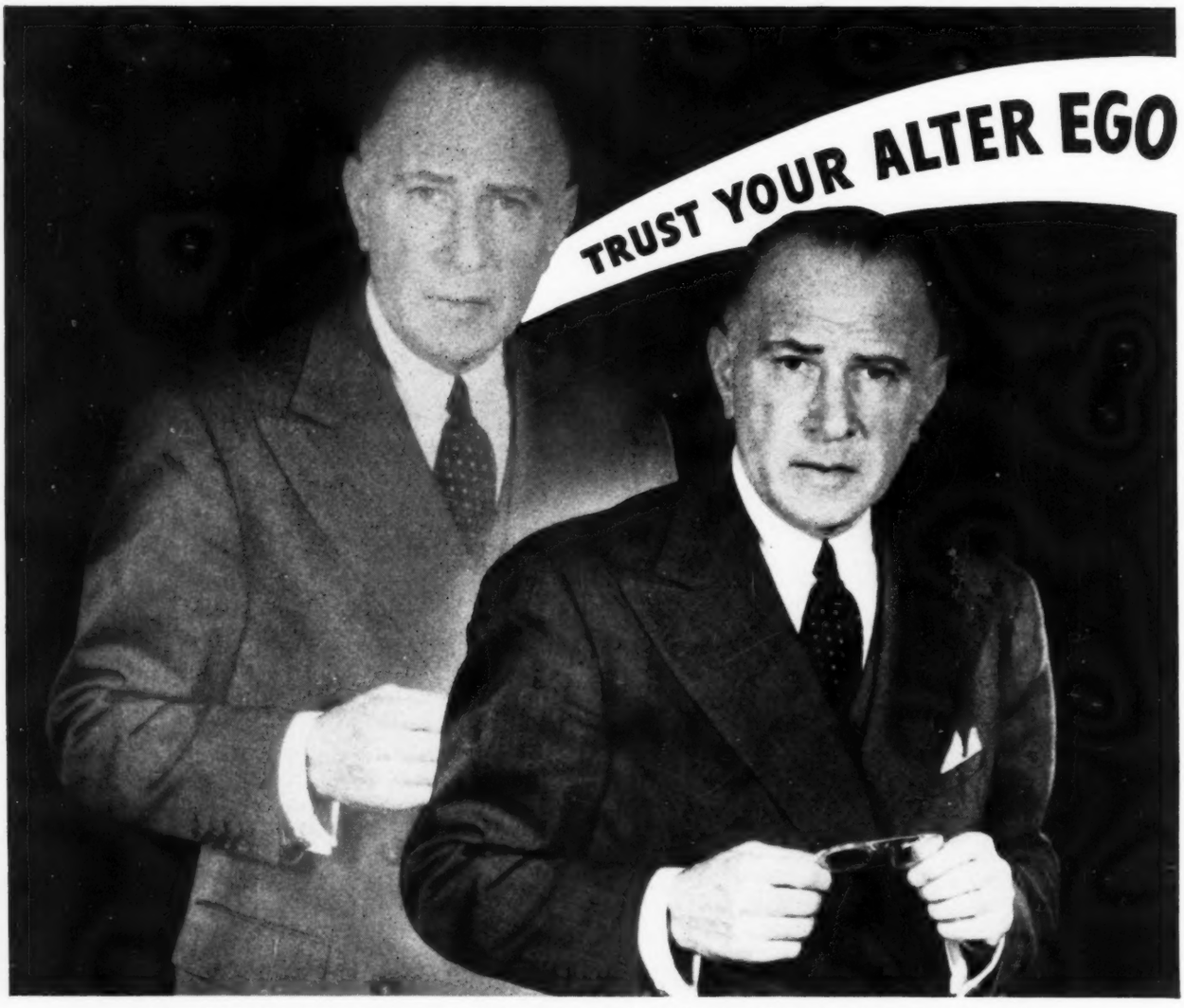
In many instances, the importance of these points is being overlooked. Often the drilling line is still wrapped around sills or snubbed in almost any way that happens to be handy.

Viewing wire line usage in general, it is believed that many of the right and wrong ways of handling wire rope are known but too often this knowledge is not put into practice. For example, it is generally recognized now that preformed wire rope offers advantages as drilling lines that make it definitely superior to the non-preformed rope where the service demanded is severe. Yet it is not until preformed rope has been used and the drillers and roughnecks from experience learn how much easier it handles and how much longer it lasts that preformed really proves its worth. The very fact that preformed rope will last longer when given reasonable care is all the more reason why increased attention should be given to the manner in which the ends of the drilling line are fastened.

Fig. 3. Another dead-end tiedown attachment that embodies correct principles for fastening long lines



Diam. of rope	*No. of clips*	*Efficiency of fastening percent*	*Efficiency of each clip percent*	*Length of wrench*
¾	5	77.39	15.5	18
⅞	5	79.13	15.8	18
1	5	77.89	15.6	24
1⅛	5	80.00	16.0	24
1¼	5	82.15	13.7	24



ALTER EGO: Literally "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

ALTER EGO: Let's talk things over. As your other self, I feel it my duty to give you some advice on how to improve your product and cut its cost.

Well, you're one fellow I don't mind getting advice from. I know you *won't try to sell me something.*

ALTER EGO: All right. Here's my suggestion. First, improve your reasoning technique. Learn to *trust your Alter Ego.* Listen to that inner voice more often.

All right, but I've had to use my conscious mind so much to ward off exposure to arc welding salesmen that I've got in the habit of trusting my surface judgment.

ALTER EGO: Yes, and because of surface reasoning you're too prone to deride that which you don't sufficiently understand. Look how others are profiting with arc welding.

But how can I understand arc welding without opening up to sales exposure?

ALTER EGO: I understand that Lincoln is a good source for arc welding information that's devoid of your pet aversion. Not a high-pressure sales talk in a book-full.

• •

LINCOLN SUGGESTS: To better acquaint yourself with arc welding procedure, why not obtain an informative discussion of this construction method as applied to *your* problems. Lincoln's booklet, "Building Better Pipe Lines" is one of a series of value to oil men.

LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

Authoritative Information on Design • Production • Welding Equipment

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 41

THE tables on the following pages are designed to save time and effort for the technician, and to assist the practical field or plant worker to solve problems commonly encountered in routine work. They are not intended nor expected to supplant technical training and make every man his own designer. Most of the tables can be understood and applied by anyone acquainted with the simple fundamentals of mathematics.

For the convenience of readers who wish to refer to the tables, each page carries in the upper right corner an index number that classifies the table according to subject matter.

All petroleum engineering literature may be indexed for reference according to the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of engineering at the University of California. When classified according to these index numbers the material follows in a logical sequence and falls into several natural divisions, as illustrated by the following outline:

Nos. P000-P339—General
Nos. P400-P499—Drilling
Nos. P500-P599—Production
Nos. P600-P699—Transportation and Storage (includes Pipe Line)
Nos. P700-P799—Refining, including
Nos. P770-P799—Natural Gasoline, which may be classified in a separate division (as shown here) if of special interest to the user.

To aid the reader in using the Decimal system, a subject index arranged alphabetically has been published, and is available from *The Petroleum Engineer*.

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DRILLING RATES AND TABLE SPEEDS CONVERTED TO FT. DRILLED PER 1000 REVOLUTIONS

150-195 r.p.m

Drilling rate			Speed of rotary table, r.p.m.									
ft. per hr.	ft. per min.	min. per ft.	150	155	160	165	170	175	180	185	190	195
1	0.02	60	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
2	.03	30	0.22	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.17
3	.05	20	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.26
4	.07	15	0.44	0.43	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.34
5	.08	12	0.56	0.54	0.52	0.51	0.49	0.48	0.46	0.45	0.44	0.43
6	0.10	10	0.67	0.65	0.63	0.61	0.59	0.57	0.56	0.54	0.53	0.51
7	.12	8.6	0.78	0.75	0.73	0.71	0.69	0.67	0.65	0.63	0.61	0.60
8	.13	7.5	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.72	0.70	0.68
9	.15	6.7	1.00	0.97	0.94	0.91	0.88	0.86	0.83	0.81	0.79	0.77
10	.17	6.0	1.11	1.08	1.04	1.01	0.98	0.95	0.93	0.90	0.88	0.85
11	0.18	5.5	1.22	1.18	1.15	1.11	1.08	1.05	1.02	0.99	0.97	0.94
12	.20	5.0	1.33	1.29	1.25	1.21	1.18	1.14	1.11	1.08	1.05	1.03
13	.22	4.6	1.44	1.40	1.35	1.31	1.27	1.24	1.20	1.17	1.14	1.11
14	.23	4.3	1.56	1.51	1.46	1.41	1.37	1.33	1.30	1.26	1.23	1.20
15	.25	4.0	1.67	1.61	1.56	1.52	1.47	1.43	1.39	1.35	1.32	1.28
16	0.27	3.8	1.78	1.72	1.67	1.62	1.57	1.52	1.48	1.44	1.40	1.37
17	.28	3.5	1.89	1.83	1.77	1.72	1.67	1.62	1.57	1.53	1.49	1.45
18	.30	3.3	2.00	1.94	1.88	1.82	1.76	1.71	1.67	1.62	1.58	1.54
19	.32	3.2	2.11	2.04	1.98	1.92	1.86	1.81	1.76	1.71	1.67	1.62
20	.33	3.0	2.22	2.15	2.08	2.02	1.96	1.90	1.85	1.80	1.75	1.71
25	0.42	2.4	2.78	2.69	2.60	2.53	2.45	2.38	2.31	2.25	2.19	2.14
30	.50	2.0	3.33	3.23	3.13	3.03	2.94	2.86	2.78	2.70	2.63	2.56
35	.58	1.7	3.89	3.76	3.65	3.54	3.43	3.33	3.24	3.15	3.07	3.00
40	.67	1.5	4.44	4.30	4.17	4.04	3.92	3.81	3.70	3.60	3.51	3.42
45	.75	1.3	5.00	4.84	4.69	4.55	4.41	4.29	4.17	4.05	3.95	3.85
50	0.83	1.2	5.56	5.38	5.21	5.05	4.90	4.76	4.63	4.50	4.39	4.27
55	.92	1.1	6.11	5.91	5.73	5.56	5.39	5.24	5.09	4.95	4.82	4.70
60	1.00	1.0	6.67	6.45	6.25	6.06	5.88	5.71	5.56	5.41	5.26	5.13
65	1.1	0.92	7.22	6.99	6.77	6.57	6.37	6.19	6.02	5.86	5.70	5.56
70	1.2	.86	7.78	7.53	7.29	7.07	6.86	6.67	6.48	6.31	6.14	5.98
75	1.25	0.80	8.33	8.06	7.81	7.58	7.35	7.14	6.94	6.76	6.58	6.41
80	1.33	.75	8.89	8.60	8.33	8.08	7.84	7.62	7.41	7.21	7.02	6.84
85	1.4	.71	9.44	9.14	8.85	8.59	8.33	8.10	7.87	7.66	7.46	7.26
90	1.50	.67	10.0	9.68	9.38	9.09	8.82	8.57	8.33	8.11	7.89	7.69
95	1.6	.63	10.6	10.2	9.90	9.60	9.31	9.05	8.80	8.56	8.33	8.12
100	1.67	0.60	11.1	10.8	10.4	10.1	9.80	9.52	9.26	9.01	8.77	8.55
105	1.75	.57	11.7	11.3	10.9	10.6	10.3	10.0	9.72	9.46	9.21	8.97
110	1.8	.55	12.2	11.8	11.5	11.1	10.8	10.5	10.2	9.91	9.65	9.40
115	1.9	.52	12.8	12.4	12.0	11.6	11.3	11.0	10.6	10.4	10.1	9.83
120	2.00	.50	13.3	12.9	12.5	12.1	11.8	11.4	11.1	10.8	10.5	10.3
125	2.1	0.48	13.9	13.4	13.0	12.6	12.3	11.9	11.6	11.3	11.0	10.7
130	2.2	.46	14.4	14.0	13.5	13.1	12.7	12.4	12.0	11.7	11.4	11.1
135	2.25	.44	15.0	14.5	14.1	13.6	13.2	12.9	12.5	12.2	11.8	11.5
140	2.33	.43	15.6	15.1	14.6	14.1	13.7	13.3	13.0	12.6	12.3	12.0
145	2.4	.41	16.1	15.6	15.1	14.6	14.2	13.8	13.4	13.1	12.7	12.4
150	2.50	0.40	16.7	16.1	15.6	15.2	14.7	14.3	13.9	13.5	13.2	12.8
155	2.6	.39	17.2	16.7	16.1	15.7	15.2	14.8	14.4	14.0	13.6	13.2
160	2.67	.38	17.8	17.2	16.7	16.2	15.7	15.2	14.8	14.4	14.0	13.7
165	2.75	.36	18.3	17.7	17.2	16.7	16.2	15.7	15.3	14.9	14.5	14.1
170	2.8	.35	18.9	18.3	17.7	17.2	16.7	16.2	15.7	15.3	14.9	14.5
175	2.9	0.34	19.4	18.8	18.2	17.7	17.2	16.7	16.2	15.8	15.4	15.0
180	3.00	.33	20.0	19.4	18.8	18.2	17.6	17.1	16.7	16.2	15.8	15.4
185	3.1	.32	20.6	19.9	19.3	18.7	18.1	17.6	17.1	16.7	16.2	15.8
190	3.2	.32	21.1	20.4	19.8	19.2	18.6	18.1	17.6	17.1	16.7	16.2
195	3.25	.31	21.7	21.0	20.3	19.7	19.1	18.6	18.1	17.6	17.1	16.7

Because of the increasing tendency among drilling engineers to correlate drilling rates with table speeds and express drilling speeds in the more reliable terms of ft. drilled per revolution of the rotary table, this table has been designed to aid in the more rapid conversion of the recorded data.

for

94

years..

"HAZARD" and "QUALITY" have been synonyms

Ever since 1846 Hazard has been making quality wire rope. That's nearly a century. That's a long time—a lot of experience. A product *has* to be good to maintain its name through three generations. It *has* to be good to keep customers coming back for Hazard ropes, *continuously*, for 30, 40, and 50 years. A product *has* to be good to merit such customer loyalty.

Now as to specific ropes:—

HAZARD LAY-SET

Preformed green strand is more and more becoming the standard rotary drilling line in all fields because it lasts longer—resists whipping—makes possible faster round trips. LAY-SET Preformed handles easier, spools better, *is safer*. And when you use green strand LAY-SET, you know it is made of Improved Plow Steel—the long-life, greater dollar value line.

HAZARD "NONPARELL"

has long been preferred by cable tool drillers. This is one of the lines that is backed by nearly a century of wire rope making experience—known to all the "old timers" as well as the younger drillers, tool pushers and superintendents as the line that gets the job done.

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Green Signifies Full Speed Ahead for National Preparedness

AMERICAN CHAIN & CABLE COMPANY, Inc.

SIZES, WEIGHTS, AND STRENGTHS—PLAIN END LINE PIPE

Size O.D., in.	Weight (plain end), lb. per ft.	Symbol	Thickness		Test pressure, lb. per sq. in.		Working pressure, lb. per sq. in. (safety factor 4)		Tons per mi.
			B.W.G. or inches in fractions	Inches in decimals	Lap-weld or seamless grade "A" 50,000-lb. ultimate fiber stress	Seamless grade "B" 60,000-lb. ultimate fiber stress	Lap-weld or seamless grade "A" 50,000-lb. ultimate fiber stress	Seamless grade "B" 60,000-lb. ultimate fiber stress	
8⅝	14.90	L	8	.165	550	....	478	....	39.357
8⅝	**16.23**	**N**	**7**	**.180**	**650**	**700**	**522**	**626**	**42.857**
8⅝	16.89	L	3/16	.1875	650	750	543	652	44.605
8⅝	18.25	N	6	.203	700	800	588	706	48.203
8⅝	19.48	N	..	.217	750	850	629	755	51.443
8⅝	19.63	L	7/32	.21875	750	850	634	761	51.846
8⅝	19.74	N	5	.220	750	850	638	765	52.134
8⅝	21.31	N	4	.238	850	950	690	828	56.279
8⅝	**22.36**	**L**	**¼**	**.250**	**850**	**1000**	**725**	**870**	**59.033**
8⅝	23.14	N	3	.259	900	1000	751	901	61.092
8⅝	**23.57**	**L**	..	**.264**	**900**	**1000**	**765**	**918**	**62.235**
8⅝	**24.69**	**H**	..	**.277**	**950**	**1100**	**803**	**963**	**65.197**
8⅝	25.06	N	9/32	.28125	1000	1100	815	978	66.163
8⅝	25.29	N	2	.284	1000	1100	823	988	66.789
8⅝	26.67	N	1	.300	1000	1200	870	1043	70.416
8⅝	**27.01**	**N**	..	**.304**	**1100**	**1200**	**881**	**1057**	**71.322**
8⅝	27.61	N	..	.311	1100	1200	901	1082	72.903
8⅝	27.74	N	5/16	.3125	1100	1200	906	1087	73.241
8⅝	**28.55**	**H**	..	**.322**	**1100**	**1300**	**933**	**1120**	**75.382**
8⅝	30.08	N	0	.340	1200	1300	986	1183	79.421
8⅝	30.40	N	11/32	.34375	1200	1400	996	1196	80.261
8⅝	**31.10**	**N**	..	**.352**	**1200**	**1400**	**1020**	**1224**	**82.106**
8⅝	31.27	N	..	.354	1200	1400	1026	1231	82.552
8⅝	**33.04**	**N**	3/8	**.375**	**1300**	**1500**	**1087**	**1304**	**87.228**
8⅝	**35.13**	**N**	..	**.400**	**1400**	**1600**	**1159**	**1391**	**92.761**
8⅝	35.65	N	13/32	.40625	1400	1600	1178	1413	94.139
8⅝	**37.22**	**N**	000	**.425**	**1500**	**1700**	**1232**	**1478**	**98.260**
8⅝	38.25	N	7/16	.4375	1500	1700	1268	1522	100.995
8⅝	**42.32**	**N**	..	**.487**	**1700**	**1900**	**1412**	**1694**	**111.743**
8⅝	**43.38**	**H**	½	**.500**	**1700**	**2000**	**1449**	**1739**	**114.544**
9	15.75	N	..	.167	550	....	464	....	41.590
9	16.95	N	7	.180	600	....	500	....	44.761
9	17.64	N	3/16	.1875	650	....	521	....	46.588
9	18.42	N	..	.196	650	....	544	....	48.652
9	19.07	N	6	.203	700	....	564	....	50.350
9	20.51	N	7/32	.21875	750	850	608	729	54.159
9	20.62	N	5	.220	750	850	611	733	54.460
9	22.27	N	4	.238	800	900	661	793	58.795
9	23.36	N	¼	.250	850	950	694	833	61.675
9	24.17	N	3	.259	850	1000	719	863	63.832
9	26.18	N	9/32	.28125	950	1100	781	938	69.138
9	26.43	N	2	.284	950	1100	789	947	69.793
9	27.87	N	1	.300	1000	1100	833	1000	73.590
9	28.90	N	5/16	.3125	1000	1200	868	1042	76.544
9	32.77	N	..	.355	1200	1300	986	1183	86.531
9	34.54	N	3/8	.375	1300	1400	1042	1250	91.193
9	36.91	N	..	.402	1300	1500	1117	1340	97.452
9	38.92	N	000	.425	1400	1600	1181	1417	102.754
9	44.02	N	..	.484	1600	1800	1344	1613	116.212
9	45.39	N	½	.500	1700	1900	1389	1667	119.829
9⅝	17.26	N	..	.171	550	....	444	....	45.579
9⅝	18.15	N	7	.180	550	....	468	....	47.934
9⅝	18.89	N	3/16	.1875	600	....	487	....	49.890
9⅝	20.42	N	6	.203	650	....	527	....	53.927
9⅝	21.97	N	7/32	.21875	700	....	568	....	58.014
9⅝	22.09	N	5	.220	700	....	571	....	58.338
9⅝	23.86	N	4	.238	750	....	618	....	62.990
9⅝	25.03	N	¼	.250	800	900	649	779	66.081
9⅝	25.90	N	3	.259	800	900	673	807	68.394
9⅝	28.06	N	9/32	.28125	900	1000	731	877	74.094
9⅝	28.33	N	2	.284	900	1000	738	885	74.796
9⅝	29.87	N	1	.300	950	1100	779	935	78.875
9⅝	31.08	N	5/16	.3125	950	1100	812	974	82.051
9⅝	33.71	N	0	.340	1100	1200	883	1060	89.010
9⅝	33.90	N	..	.342	1100	1200	888	1066	89.514
9⅝	37.04	N	3/8	.375	1200	1300	974	1169	97.801
9⅝	42.92	N	7/16	.4375	1400	1500	1136	1364	113.332
9⅝	48.72	N	½	.500	1600	1800	1299	1558	128.641

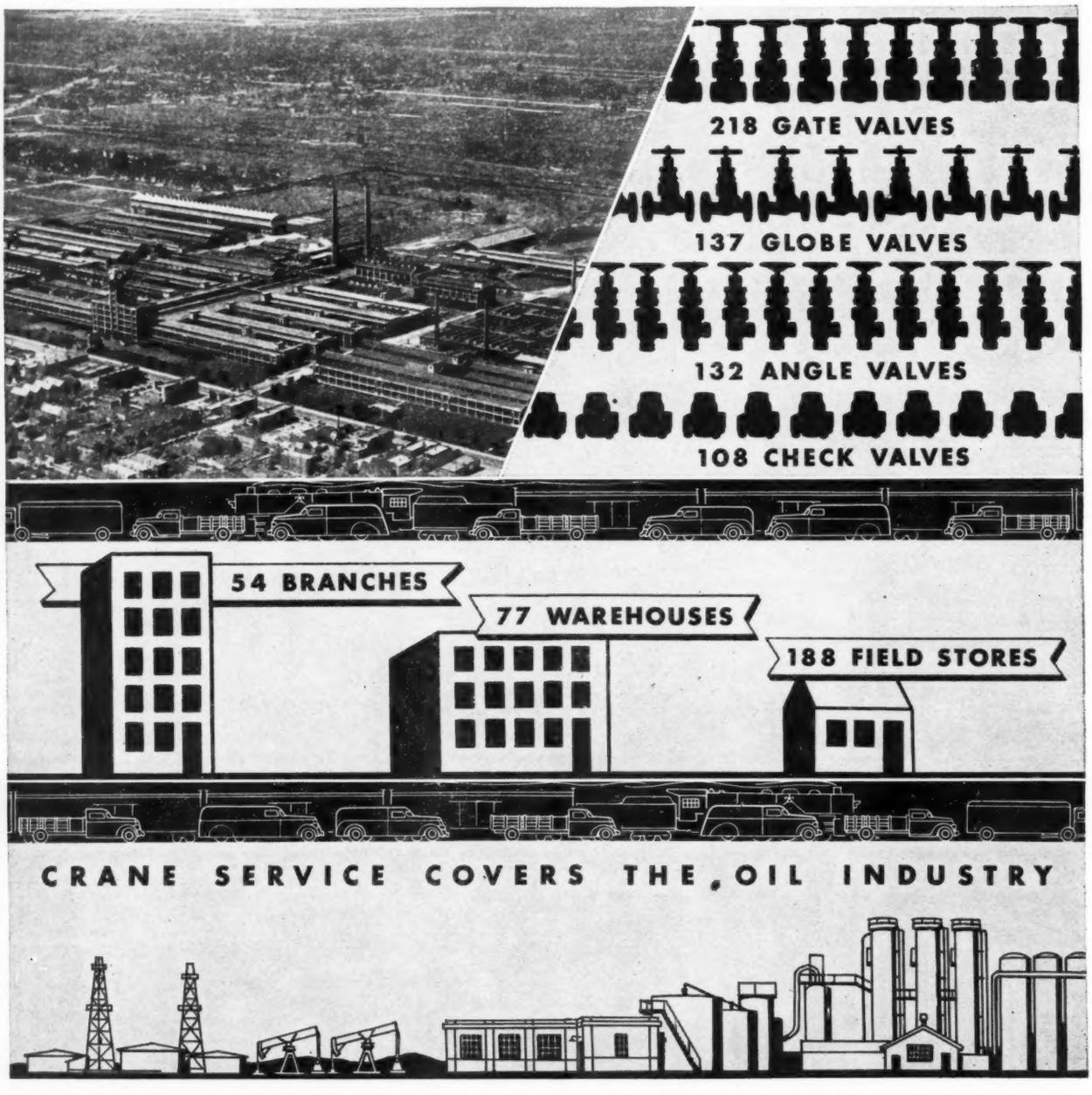
†This table may be filed under P 622.3, if preferred.

For notes accompanying table see sheet 1 P 615.23†.

Courtesy National Tube Company, Bulletin No. 23.

VALVES...
When and Where You Need Them!

The world's greatest line of valves permits proper selection for every application. Vast manufacturing resources provide an ample supply. The most complete distribution system assures convenient availability to the oil and gas industry everywhere.



1940 OUR 85th YEAR

CRANE

CRANE CO., GENERAL OFFICES:
836 S. MICHIGAN AVE., CHICAGO

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

SAPONIFICATION NUMBERS—OILS CONTAINING MORE THAN 30% FATTY OILS—METHOD A

D = 20.0 to 24.9

Value of D[1]	Weight of oil sample, w. grams.																				
	4.90	4.91	4.92	4.93	4.94	4.95	4.96	4.97	4.98	4.99	5.00	5.01	5.02	5.03	5.04	5.05	5.06	5.07	5.08	5.09	5.10
20.0	114.	114.	114.	114.	114.	113.	113.	113.	113.	112.	112.	112.	112.	112.	111.	111.	111.	111.	110.	110.	110.
20.1	115.	115.	115.	114.	114.	114.	114.	113.	113.	113.	113.	113.	112.	112.	112.	112.	111.	111.	111.	111.	111.
20.2	116.	115.	115.	115.	115.	114.	114.	114.	114.	114.	113.	113.	113.	113.	112.	112.	112.	112.	112.	111.	111.
20.3	116.	116.	116.	116.	115.	115.	115.	115.	114.	114.	114.	114.	113.	113.	113.	113.	113.	112.	112.	112.	112.
20.4	117.	117.	116.	116.	116.	116.	115.	115.	115.	115.	114.	114.	114.	114.	114.	113.	113.	113.	113.	112.	112.
20.5	117.	117.	117.	117.	116.	116.	116.	116.	115.	115.	115.	115.	115.	114.	114.	114.	114.	113.	113.	113.	113.
20.6	118.	118.	117.	117.	117.	117.	116.	116.	116.	116.	116.	115.	115.	115.	115.	114.	114.	114.	114.	114.	113.
20.7	118.	118.	118.	118.	118.	117.	117.	117.	117.	116.	116.	116.	116.	115.	115.	115.	115.	115.	114.	114.	114.
20.8	119.	119.	119.	118.	118.	118.	118.	117.	117.	117.	117.	116.	116.	116.	116.	116.	115.	115.	115.	115.	114.
20.9	120.	119.	119.	119.	119.	118.	118.	118.	118.	117.	117.	117.	117.	117.	116.	116.	116.	116.	115.	115.	115.
21.0	120.	120.	120.	119.	119.	119.	119.	119.	118.	118.	118.	118.	117.	117.	117.	117.	116.	116.	116.	116.	116.
21.1	121.	121.	120.	120.	120.	120.	119.	119.	119.	119.	118.	118.	118.	118.	117.	117.	117.	117.	117.	116.	116.
21.2	121.	121.	121.	121.	120.	120.	120.	120.	119.	119.	119.	119.	118.	118.	118.	118.	118.	117.	117.	117.	117.
21.3	122.	122.	121.	121.	121.	121.	120.	120.	120.	120.	119.	119.	119.	119.	119.	118.	118.	118.	118.	117.	117.
21.4	123.	122.	122.	122.	122.	121.	121.	121.	121.	120.	120.	120.	120.	119.	119.	119.	119.	118.	118.	118.	118.
21.5	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.	121.	120.	120.	120.	120.	119.	119.	119.	119.	118.	118.
21.6	124.	123.	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.	121.	120.	120.	120.	120.	120.	119.	119.	119.
21.7	124.	124.	124.	123.	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.	121.	121.	120.	120.	120.	120.	119.
21.8	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.	121.	120.	120.	120.
21.9	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.	121.	120.
22.0	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.	122.	122.	122.	122.	121.	121.	121.
22.1	127.	126.	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.	123.	122.	122.	122.	122.
22.2	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.	122.	122.
22.3	128.	127.	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.	123.	123.
22.4	128.	128.	128.	127.	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.	123.	123.
22.5	129.	129.	128.	128.	128.	128.	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.	125.	124.	124.	124.	124.
22.6	129.	129.	129.	129.	128.	128.	128.	128.	127.	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.	125.	124.
22.7	130.	130.	129.	129.	129.	129.	128.	128.	128.	128.	127.	127.	127.	127.	126.	126.	126.	126.	125.	125.	125.
22.8	131.	130.	130.	130.	129.	129.	129.	129.	128.	128.	128.	128.	127.	127.	127.	127.	126.	126.	126.	126.	125.
22.9	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	128.	128.	128.	128.	127.	127.	127.	127.	126.	126.	126.
23.0	132.	131.	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	129.	128.	128.	128.	128.	127.	127.	127.	127.
23.1	132.	132.	132.	131.	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	129.	128.	128.	128.	128.	127.	127.
23.2	133.	133.	132.	132.	132.	131.	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	129.	128.	128.	128.	128.
23.3	133.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	129.	128.	128.
23.4	134.	134.	133.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.	130.	130.	130.	130.	129.	129.	129.	129.
23.5	135.	134.	134.	134.	133.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.	131.	130.	130.	130.	130.	129.
23.6	135.	135.	135.	134.	134.	134.	133.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.	131.	130.	130.	130.
23.7	136.	135.	135.	135.	135.	134.	134.	134.	133.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.	131.	130.
23.8	136.	136.	136.	135.	135.	135.	135.	134.	134.	134.	134.	133.	133.	133.	132.	132.	132.	132.	131.	131.	131.
23.9	137.	137.	136.	136.	136.	135.	135.	135.	135.	134.	134.	134.	134.	133.	133.	133.	132.	132.	132.	132.	131.
24.0	137.	137.	137.	137.	136.	136.	136.	135.	135.	135.	135.	134.	134.	134.	134.	133.	133.	133.	133.	132.	132.
24.1	138.	138.	137.	137.	137.	137.	136.	136.	136.	135.	135.	135.	135.	134.	134.	134.	134.	133.	133.	133.	133.
24.2	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.	135.	135.	135.	135.	134.	134.	134.	134.	133.	133.
24.3	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.	136.	135.	135.	135.	134.	134.	134.	134.
24.4	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.	136.	135.	135.	135.	134.	134.
24.5	140.	140.	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.	136.	135.	135.	135.
24.6	141.	141.	140.	140.	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.	136.	135.
24.7	141.	141.	141.	141.	140.	140.	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.	136.	136.
24.8	142.	142.	141.	141.	141.	141.	140.	140.	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.	137.	136.
24.9	143.	142.	142.	142.	141.	141.	141.	141.	140.	140.	140.	139.	139.	139.	139.	138.	138.	138.	137.	137.	137.

[1] D = difference between the number of milliliters of 0.5*N* HCl required for the determination and the average of the two blanks run on the alcoholic potassium hydroxide solution.

The above saponification numbers are calculated by the formula: $\text{Saponification number} = \frac{D \times 28.05}{w}$

This formula is from "Test for Saponification Number," A.S.T.M. (D94-39T).

For additional notes, see tables indexed P 747.501.10.

ELECT CHAPMAN'S 960 for a 5-Year Term!

. . . and sweep Small-Valve Troubles out of office!

For an honest administration of all valve jobs on field and refinery lines up to 2" . . . Chapman's List 960 is the majority choice. Because this tough, forged-steel gate valve not only promises . . . *it guarantees* . . . to work without repairs or replacements for 5 years at least.

So vote Chapman's List 960 into all jobs with pressures up to 800 lb. at 750°, or 1500 lb. cold working pressure. Sizes available from ¼" to 2", with screw ends for threaded pipe . . . and made in both outside and inside screw models, with rising stem . . . and with stainless steel parts for which you don't have to stock replacements. Make List 960 *your* choice, and sweep small-valve troubles out of your office! Write, wire or phone the nearest Chapman branch *today*.

CHAPMAN LIST 960
for all Small Valve Work

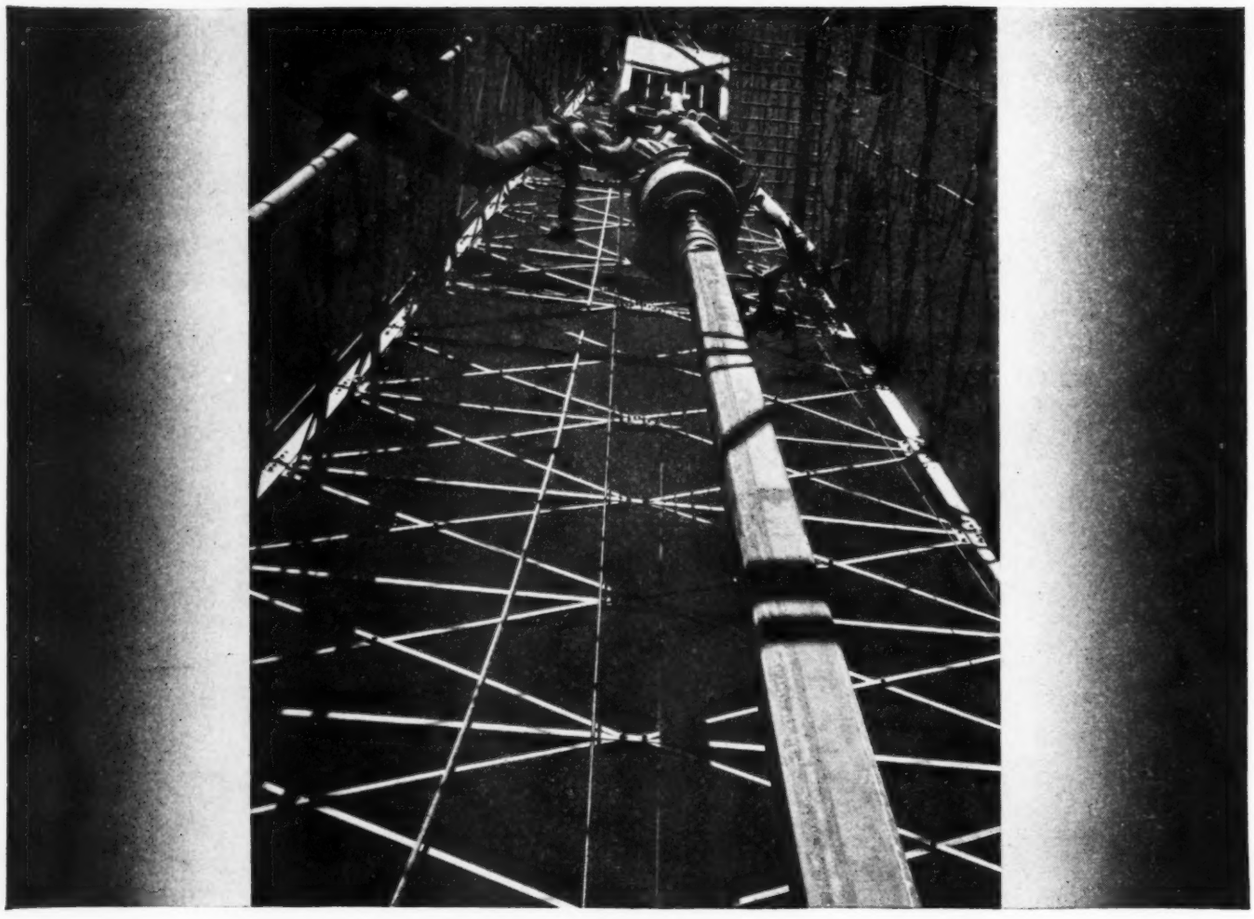
These tough, all-purpose Forged Steel Gate Valves are Chapman's answer to small-valve trouble. For real economy they challenge comparison with valves of any other type or material. They are available in all sizes from ¼" to 2", inside or outside screw.

The CHAPMAN VALVE MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

TOTAL REVOLUTIONS OF ROTARY TABLE REDUCED TO R.P.M.

Total no. of revolutions made by rotary table	Elapsed time or period of test, hr.											
	1	1½	2	2½	3	3½	4	4½	5	6	7	8
32,500	542	361	271	217	181	155	135	120	108	90	77	68
33,000	550	367	275	220	183	157	138	122	110	92	79	69
33,500	558	372	279	223	186	160	140	124	112	93	80	70
34,000	567	378	283	227	189	162	142	126	113	94	81	71
34,500	575	383	287	230	192	164	144	128	115	96	82	72
35,000	583	389	292	233	194	167	146	130	117	97	83	73
35,500	592	394	296	237	197	169	148	131	118	99	85	74
36,000	600	400	300	240	200	171	150	133	120	100	86	75
36,500		406	304	243	203	174	152	135	122	101	87	76
37,000		411	308	247	206	176	154	137	123	103	88	77
37,500		417	312	250	208	179	156	139	125	104	89	78
38,000		422	317	253	211	181	158	141	127	106	90	79
38,500		428	321	257	214	183	160	143	128	107	92	80
39,000		433	325	260	217	186	163	144	130	108	93	81
39,500		439	329	263	219	188	165	146	132	110	94	82
40,000		444	333	267	222	190	167	148	133	111	95	83
40,500		450	337	270	225	193	169	150	135	113	96	84
41,000		456	342	273	228	195	171	152	137	114	98	85
41,500		461	346	277	231	198	173	154	138	115	99	86
42,000		467	350	280	233	200	175	156	140	117	100	87
42,500		472	354	283	236	202	177	157	142	118	101	89
43,000		478	358	287	239	205	179	159	143	119	102	90
43,500		483	362	290	242	207	181	161	145	121	104	91
44,000		489	367	293	244	210	183	163	147	122	105	92
44,500		494	371	297	247	212	185	165	148	124	106	93
45,000		500	375	300	250	214	188	167	150	125	107	94
45,500		506	379	303	253	217	190	169	152	126	108	95
46,000		511	383	307	256	219	192	170	153	128	110	96
46,500		517	387	310	258	221	194	172	155	129	111	97
47,000		522	392	313	261	224	196	174	157	131	112	98
47,500		528	396	317	264	226	198	176	158	132	113	99
48,000		533	400	320	267	229	200	178	160	133	114	100
48,500		539	404	323	269	231	202	180	162	135	115	101
49,000		544	408	327	272	233	204	181	163	136	117	102
49,500		550	412	330	275	236	206	183	165	138	118	103
50,000		556	417	333	278	238	208	185	167	139	119	104
50,500		561	421	337	281	240	210	187	168	140	120	105
51,000		567	425	340	283	243	213	189	170	142	121	106
51,500		572	429	343	286	245	215	191	172	143	123	107
52,000		578	433	347	289	248	217	193	173	144	124	108
52,500		583	437	350	292	250	219	194	175	146	125	109
53,000		589	442	353	294	252	221	196	177	147	126	110
53,500		594	446	357	297	255	223	198	178	149	127	111
54,000		600	450	360	300	257	225	200	180	150	129	112
54,500			454	363	303	260	227	202	182	151	130	114
55,000			458	367	306	262	229	204	183	153	131	115
55,500			462	370	308	264	231	206	185	154	132	116
56,000			467	373	311	267	233	207	187	156	133	117
56,500			471	377	314	269	235	209	188	157	135	118
57,000			475	380	317	271	238	211	190	158	136	119
57,500			479	383	319	274	240	213	192	160	137	120
58,000			483	387	322	276	242	215	193	161	138	121
58,500			487	390	325	279	244	217	195	163	139	122
59,000			492	393	328	281	246	219	197	164	140	123
59,500			496	397	331	283	248	220	198	165	142	124
60,000			500	400	333	286	250	222	200	167	143	125
60,500			504	403	336	288	252	224	202	168	144	126
61,000			508	407	339	290	254	226	203	169	145	127
61,500			512	410	342	293	256	228	205	171	146	128
62,000			517	413	344	295	258	230	207	172	148	129

See footnote of tables indexed P 425.262.



"SNAP THE WHIP" IS NO GAME FOR THE KELLY

When a Kelly bar gets a permanent crook or bend there's little to be done except to take it out of service and straighten it.

Consequently it pays to make certain that the Kelly will stand up to its work without going out of true.

Chromium-Molybdenum (SAE 4140) Steel is making good in Kelly bar service. It has high tensile strength, with uniform properties throughout the mass, and the hardness needed to stand rough usage and to resist abrasion from mud passing through the bore.

Furthermore, because of the relatively high yield tensile ratio of Chrome-Moly (SAE 4140), a Kelly bar made of it can be loaded nearer the tensile strength limit without danger of taking a permanent bend.

This is only one of the Molybdenum steels which are serving so effectively in the oil fields. They are all described in our technical book, "Molybdenum Steels in Oil Production", which will be sent free on request.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

LENGTH OF CASING STRINGS OCCUPIED BY CEMENT SLURRY

Volume of slurry formed per sack, Cu. ft.	Slurry characteristics: Water content per sack, gal.	Water content per sack, cu. ft.	Water content per sack, lb.	Weight of slurry, lb. per gal.	Nominal tubing size, in.: 4¾	5½	6	6⅝	7	7⅝	8⅝	9
					I.D. of tubing, in.: 4.082	4.974*	5.424*	5.921*	6.336*	6.875*	7.825*	8.196*
					(figures below are tubing lengths in ft. occupied by a 10-sack batch)							
0.95	**3.50**	0.47	29.3	**17.4**	105	70	59	50	43	37	28	26
.98	**3.75**	0.50	31.3	**17.1**	108	73	61	51	45	38	29	27
1.01	**4.00**	0.53	33.4	**16.9**	111	75	63	53	46	39	30	28
1.05	**4.25**	0.57	35.5	**16.5**	116	78	65	55	48	41	31	29
1.08	**4.50**	0.60	37.6	**16.3**	119	80	67	56	49	42	32	29
1.11	**4.75**	0.63	39.6	**16.1**	122	82	69	58	51	43	33	30
1.15	**5.00**	0.67	41.7	**15.8**	127	85	72	60	53	45	34	31
1.18	**5.25**	0.70	43.8	**15.6**	130	87	74	62	54	46	35	32
1.22	**5.50**	0.74	45.9	**15.3**	134	90	76	64	56	47	37	33
1.25	**5.75**	0.77	48.0	**15.2**	138	93	78	65	57	48	37	34
1.28	**6.00**	0.80	50.1	**15.1**	141	95	80	67	58	50	38	35
1.32	**6.25**	0.84	52.2	**14.8**	145	98	82	69	60	51	40	36
1.35	**6.50**	0.87	54.2	**14.7**	149	100	84	71	62	52	40	37
1.38	**6.75**	0.90	56.3	**14.6**	152	102	86	72	63	54	41	38
1.42	**7.00**	0.94	58.4	**14.3**	156	105	88	74	65	55	43	39
1.45	**7.25**	0.97	60.5	**14.3**	160	107	90	76	66	56	43	40
1.48	**7.50**	1.00	62.6	**14.1**	163	110	92	77	68	57	44	40
1.52	**7.75**	1.04	64.7	**14.0**	167	113	95	79	69	59	46	41
1.55	**8.00**	1.07	66.8	**13.9**	171	115	97	81	71	60	46	42
1.58	**8.25**	1.10	68.9	**13.8**	174	117	98	83	72	61	47	43
1.62	**8.50**	1.14	70.9	**13.6**	178	120	101	85	74	63	49	44
1.65	**8.75**	1.17	73.0	**13.5**	182	122	103	86	75	64	49	45
1.68	**9.00**	1.20	75.1	**13.5**	185	124	105	88	77	65	50	46
1.72	**9.25**	1.24	77.2	**13.3**	189	127	107	90	79	67	52	47
1.75	**9.50**	1.27	79.3	**13.2**	193	130	109	92	80	68	52	48
1.78	**9.75**	1.30	81.4	**13.2**	196	132	111	93	81	69	53	49
1.82	**10.0**	1.34	83.5	**13.0**	200	135	113	95	83	71	54	50
1.85	**10.25**	1.37	85.5	**13.0**	204	137	115	97	84	72	55	50
1.88	**10.5**	1.40	87.6	**12.9**	207	139	117	98	86	73	56	51
1.92	**10.75**	1.44	89.7	**12.8**	211	142	120	100	88	74	57	52
1.95	**11.0**	1.47	91.8	**12.7**	215	145	122	102	89	76	58	53
1.98	**11.25**	1.50	93.9	**12.7**	218	147	123	104	90	77	59	54
2.02	**11.5**	1.54	96.0	**12.6**	222	150	126	106	92	78	60	55
1.05	**11.75**	1.57	98.1	**12.5**	226	152	128	107	94	80	61	56
2.08	**12.0**	1.60	100.	**12.5**	229	154	130	109	95	81	62	57
2.12	**12.25**	1.64	102.	**12.4**	233	157	132	111	97	82	63	58
2.15	**12.5**	1.67	104.	**12.3**	237	159	134	112	98	83	64	59
2.18	**12.75**	1.70	106.	**12.3**	240	162	136	114	100	85	65	60
2.22	**13.0**	1.74	109.	**12.2**	244	165	138	116	101	86	66	61
2.25	**13.25**	1.77	111.	**12.2**	248	167	140	118	103	87	67	61
2.28	**13.5**	1.80	113.	**12.1**	251	169	142	119	104	88	68	62
2.32	**13.75**	1.84	115.	**12.0**	255	172	145	121	106	90	69	63
2.35	**14.0**	1.87	117.	**12.0**	259	174	146	123	107	91	70	64
2.38	**14.25**	1.90	119.	**12.0**	262	176	148	124	109	92	71	65
2.42	**14.5**	1.94	121.	**11.9**	266	179	151	127	111	94	72	66
2.45	**14.75**	1.97	123.	**11.8**	270	182	153	128	112	95	73	67

Note: Above calculations are based on cement weighing 94 lb. per 1 cu. ft. sack. It is assumed that 1 sack of cement occupies 0.484 cu. ft. when mixed. Inclusion of data for high water-cement ratios in the lower part of the table should not be construed as a recommendation of their use when high-strength cement is desired.

*Selected as average for the various weights of casing available in this size.

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● Pump in action on deep oil well which was protected against lay-downs by using Unaflo Oil-Well Cement—the easy-flowing hard-setting cement with the retarded set.

IN Louisiana's oil diggin's a well had been drilled to 13,255 ft. The next step—cementing—looked like a nightmare. The operators had to cement a 7″ casing at 12,000 ft. and a short string of 5″ casing inside the 7-incher at the bottom. And bottom hole temperature was 297°! What would *you* have done?

The operators knew they couldn't take a chance with an ordinary cement. Too much was at stake. So they chose a cement they *knew* would stay easily pumpable all the way down that long, hot string... Unaflo Oil-Well Cement! And the result? Complete success! Unaflo again turned a tough one into just another job. The 7″ casing took 450 bags, and the 5″ took 125 bags of this easy-flowing, hard-setting cement with the retarded set.

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PE-U-13

UNIVERSAL ATLAS OIL WELL CEMENTS

TOTAL REVOLUTIONS OF ROTARY TABLE REDUCED TO R.P.M.

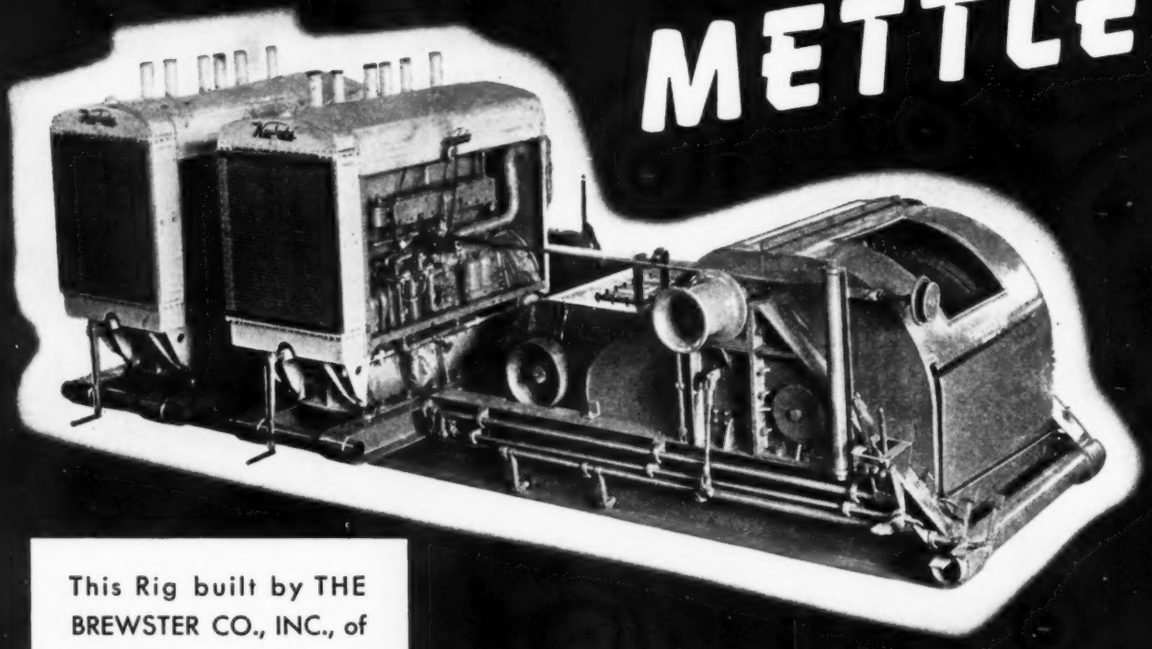
5-60 min.

Total no. of revolutions made by rotary table	Elapsed time or period of test, min.											
	5	10	15	20	25	30	35	40	45	50	55	60
5,000		500	333	250	200	167	143	125	111	100	91	83
5,100		510	340	255	204	170	146	128	113	102	93	85
5,200		520	347	260	208	173	149	130	116	104	95	87
5,300		530	353	265	212	177	151	133	118	106	96	88
5,400		540	360	270	216	180	154	135	120	108	98	90
5,500		550	367	275	220	183	157	138	122	110	100	92
5,600		560	373	280	224	187	160	140	124	112	102	93
5,700		570	380	285	228	190	163	143	127	114	104	95
5,800		580	387	290	232	193	166	145	129	116	105	97
5,900		590	393	295	236	197	169	148	131	118	107	98
6,000		600	400	300	240	200	171	150	133	120	109	100
6,100			407	305	244	203	174	153	136	122	111	102
6,200			413	310	248	207	177	155	138	124	113	103
6,300			420	315	252	210	180	158	140	126	115	105
6,400			427	320	256	213	183	160	142	128	116	107
6,500			433	325	260	217	186	163	144	130	118	108
6,600			440	330	264	220	189	165	147	132	120	110
6,700			447	335	268	223	191	168	149	134	122	112
6,800			453	340	272	227	194	170	151	136	124	113
6,900			460	345	276	230	197	173	153	138	125	115
7,000			467	350	280	233	200	175	156	140	127	117
7,100			473	355	284	237	203	178	158	142	129	118
7,200			480	360	288	240	206	180	160	144	131	120
7,300			487	365	292	243	209	183	162	146	133	122
7,400			493	370	296	247	211	185	164	148	135	123
7,500			500	375	300	250	214	188	167	150	136	125
7,600			507	380	304	253	217	190	169	152	138	127
7,700			513	385	308	257	220	193	171	154	140	128
7,800			520	390	312	260	223	195	173	156	142	130
7,900			527	395	316	263	226	198	176	158	144	132
8,000			533	400	320	267	229	200	178	160	145	133
8,100			540	405	324	270	231	203	180	162	147	135
8,200			547	410	328	273	234	205	182	164	149	137
8,300			553	415	332	277	237	208	184	166	151	138
8,400			560	420	336	280	240	210	187	168	153	140
8,500			567	425	340	283	243	213	189	170	155	142
8,600			573	430	344	287	246	215	191	172	156	143
8,700			580	435	348	290	249	218	193	174	158	145
8,800			587	440	352	293	251	220	196	176	160	147
8,900			593	445	356	297	254	223	198	178	162	148
9,000			600	450	360	300	257	225	200	180	164	150
9,100				455	364	303	260	228	202	182	165	152
9,200				460	368	307	263	230	204	184	167	153
9,300				465	372	310	266	233	207	186	169	155
9,400				470	376	313	269	235	209	188	171	157
9,500				475	380	317	271	238	211	190	173	158
9,600				480	384	320	274	240	213	192	175	160
9,700				485	388	323	277	243	216	194	176	162
9,800				490	392	327	280	245	218	196	178	163
9,900				495	396	330	283	248	220	198	180	165
10,000				500	400	333	286	250	222	200	182	167
10,100				505	404	337	289	253	224	202	184	168
10,200				510	408	340	291	255	227	204	185	170
10,300				515	412	343	294	258	229	206	187	172
10,400				520	416	347	297	260	231	208	189	173

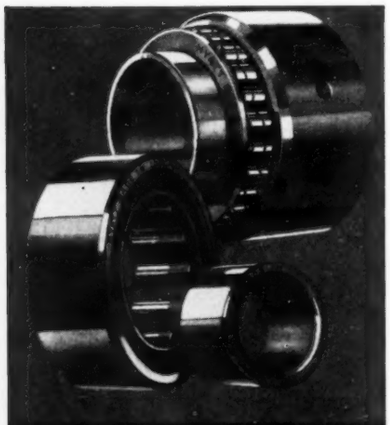
Odometers or other means of recording total number of turns made by the rotary table are being used more and more by progressive drilling companies. This table is designed to aid in determining quickly the average r.p.m. during a test period.

Table 425.263. gives the r.p.m. during periods of 1 to 8 hr. inclusive.

PROVING THEIR METTLE



This Rig built by THE BREWSTER CO., INC., of Shreveport, La., has a full quota of Hyatt Roller Bearings to keep it always on the go.



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DRILLING RATES AND TABLE SPEEDS CONVERTED TO FT. DRILLED PER 1000 REVOLUTIONS

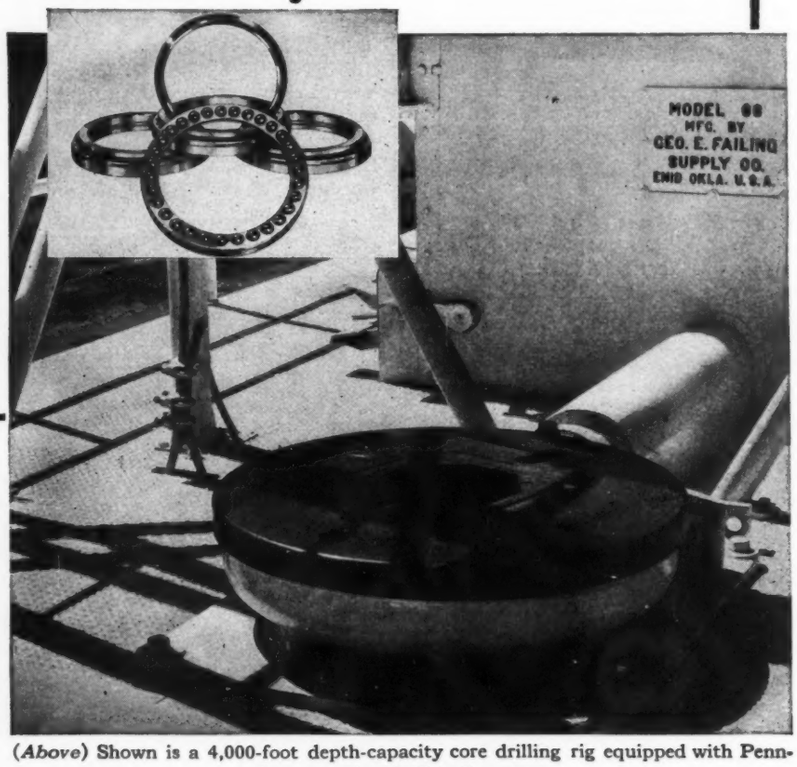
200-245 r.p.m.

Drilling rate			Speed of rotary table, r.p.m.									
ft. per hr.	ft. per min.	min. per ft.	200	205	210	215	220	225	230	235	240	245
1	0.02	60	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07
2	.03	30	0.17	0.16	0.16	0.16	0.15	0.15	0.14	0.14	0.14	0.14
3	.05	20	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20
4	.07	15	0.33	0.33	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.27
5	.08	12	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.34
6	0.10	10	0.50	0.49	0.48	0.47	0.45	0.44	0.44	0.43	0.42	0.41
7	.12	8.6	0.58	0.57	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.48
8	.13	7.5	0.67	0.65	0.64	0.62	0.61	0.59	0.58	0.57	0.56	0.54
9	.15	6.7	0.75	0.73	0.71	0.70	0.68	0.67	0.65	0.64	0.63	0.61
10	.17	6.0	0.83	0.81	0.79	0.78	0.76	0.74	0.72	0.71	0.69	0.68
11	0.18	5.5	0.92	0.89	0.87	0.85	0.83	0.82	0.80	0.78	0.76	0.75
12	.20	5.0	1.00	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.83	0.82
13	.22	4.6	1.08	1.06	1.03	1.01	0.98	0.96	0.94	0.92	0.90	0.88
14	.23	4.3	1.17	1.14	1.11	1.09	1.06	1.04	1.01	0.99	0.97	0.95
15	.25	4.0	1.25	1.22	1.19	1.16	1.14	1.11	1.09	1.06	1.04	1.02
16	0.27	3.8	1.33	1.30	1.27	1.24	1.21	1.19	1.16	1.13	1.11	1.09
17	.28	3.5	1.42	1.38	1.35	1.32	1.29	1.26	1.23	1.21	1.18	1.16
18	.30	3.3	1.50	1.46	1.43	1.40	1.36	1.33	1.30	1.28	1.25	1.22
19	.32	3.2	1.58	1.54	1.51	1.47	1.44	1.41	1.38	1.35	1.32	1.29
20	.33	3.0	1.67	1.63	1.59	1.55	1.52	1.48	1.45	1.42	1.39	1.36
25	0.42	2.4	2.08	2.03	1.98	1.94	1.89	1.85	1.81	1.77	1.74	1.70
30	.50	2.0	2.50	2.44	2.38	2.33	2.27	2.22	2.17	2.13	2.08	2.04
35	.58	1.7	2.92	2.85	2.78	2.71	2.65	2.59	2.54	2.48	2.43	2.38
40	.67	1.5	3.33	3.25	3.17	3.10	3.03	2.96	2.90	2.84	2.78	2.72
45	.75	1.3	3.75	3.66	3.57	3.49	3.41	3.33	3.26	3.19	3.12	3.06
50	0.83	1.2	4.17	4.07	3.97	3.88	3.79	3.70	3.62	3.55	3.47	3.40
55	.92	1.1	4.58	4.47	4.37	4.26	4.17	4.07	3.99	3.90	3.82	3.74
60	1.00	1.0	5.00	4.88	4.76	4.65	4.55	4.44	4.35	4.26	4.17	4.08
65	1.1	0.92	5.42	5.28	5.16	5.04	4.92	4.81	4.71	4.61	4.51	4.42
70	1.2	0.86	5.83	5.69	5.56	5.43	5.30	5.19	5.07	4.96	4.86	4.76
75	1.25	0.80	6.25	6.10	5.95	5.81	5.68	5.56	5.43	5.32	5.21	5.10
80	1.33	0.75	6.67	6.50	6.35	6.20	6.06	5.93	5.80	5.67	5.56	5.44
85	1.4	0.71	7.08	6.91	6.75	6.59	6.44	6.30	6.16	6.03	5.90	5.78
90	1.50	0.67	7.50	7.32	7.14	6.98	6.82	6.67	6.52	6.38	6.25	6.12
95	1.6	0.63	7.92	7.72	7.54	7.36	7.20	7.04	6.88	6.74	6.60	6.46
100	1.67	0.60	8.33	8.13	7.94	7.75	7.58	7.41	7.25	7.09	6.94	6.80
105	1.75	.57	8.75	8.54	8.33	8.14	7.95	7.78	7.61	7.45	7.29	7.14
110	1.8	.55	9.17	8.94	8.73	8.53	8.33	8.15	7.97	7.80	7.64	7.48
115	1.9	.52	9.58	9.35	9.13	8.91	8.71	8.52	8.33	8.16	7.99	7.82
120	2.00	.50	10.0	9.76	9.52	9.30	9.09	8.89	8.70	8.51	8.33	8.16
125	2.1	0.48	10.4	10.2	9.92	9.69	9.47	9.26	9.06	8.87	8.68	8.50
130	2.2	.46	10.8	10.6	10.3	10.1	9.85	9.63	9.42	9.22	9.03	8.84
135	2.25	.44	11.2	11.0	10.7	10.5	10.2	10.0	9.78	9.57	9.37	9.18
140	2.33	.43	11.7	11.4	11.1	10.9	10.6	10.4	10.1	9.93	9.72	9.52
145	2.4	.41	12.1	11.8	11.5	11.2	11.0	10.7	10.5	10.3	10.1	9.86
150	2.50	0.40	12.5	12.2	11.9	11.6	11.4	11.1	10.9	10.6	10.4	10.2
155	2.6	.39	12.9	12.6	12.3	12.0	11.7	11.5	11.2	11.0	10.8	10.5
160	2.67	.38	13.3	13.0	12.7	12.4	12.1	11.9	11.6	11.3	11.1	10.9
165	2.75	.36	13.7	13.4	13.1	12.8	12.5	12.2	12.0	11.7	11.5	11.2
170	2.8	.35	14.2	13.8	13.5	13.2	12.9	12.6	12.3	12.1	11.8	11.6
175	2.9	0.34	14.6	14.2	13.9	13.6	13.3	13.0	12.7	12.4	12.2	11.9
180	3.00	.33	15.0	14.6	14.3	14.0	13.6	13.3	13.0	12.8	12.5	12.2
185	3.1	.32	15.4	15.0	14.7	14.3	14.0	13.7	13.4	13.1	12.8	12.6
190	3.2	.32	15.8	15.4	15.1	14.7	14.4	14.1	13.8	13.5	13.2	12.9
195	3.25	.31	16.2	15.9	15.5	15.1	14.8	14.4	14.1	13.8	13.5	13.3

Because of the increasing tendency among drilling engineers to correlate drilling rates with table speeds and express drilling speeds in the more reliable terms of ft. drilled per revolution of the rotary table, this table has been designed to aid in the more rapid conversion of the recorded data.

Low-Cost Prospecting

BANTAM'S ANGULAR CONTACT BEARINGS BOOST SPEED OF PENNINGTON SLIM-HOLE ROTARIES



(*Above*) Shown is a 4,000-foot depth-capacity core drilling rig equipped with Pennington enclosed oil-bath rotary.

Fast hole drilling and economical prospecting are outstanding advantages of the Slim-Hole Rotaries made by Pennington Signaling Core Barrel. Design is a 12¾" for approximately 75 ton loads at 100 r.p.m., a static load of 150 tons; these rotaries allow sharp reductions in costs, yet give as complete geological data as larger sizes.

High rotary speed of 600 RPM makes drilling fast, maintains hole close to vertical, increases sensitivity toward formation changes. And Bantam's Angular Contact Ball Bearings, taking both thrust and radial loads, are an important factor in making these high speeds possible. "Bantam's Angular Contact Ball Bearings have given absolutely reliable high-speed service in these rotaries, contributing largely to the many repeat orders received," says Mr. Harry Pennington, President.

And rotary tables are just one of the many types of oil well equipment in which Bantam Bearings are giving completely satisfactory service. You can profit by Bantam's skill in the design of bearings for oil well service—specify Bantam Bearings when you buy equipment.

BANTAM'S ENGINEERING COUNSEL is based on extensive experience in the design and application of bearings for every type of oil well service. For unbiased, authoritative advice on bearing selection, more and more manufacturers TURN TO BANTAM.

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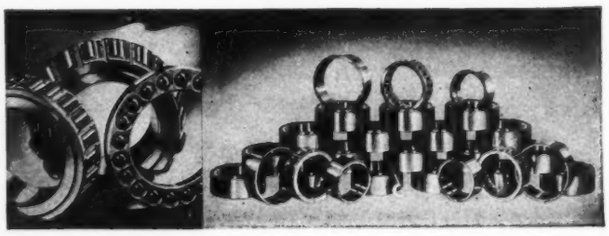
(*Below*) **BANTAM'S JOURNAL ROLLER BEARINGS** find wide use in the oil fields for radial loads beyond the range of the Quill Bearing. Crown blocks, traveling blocks, swivels, draw-works, and rotary drives are a few typical applications.



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Pressure Distribution About a Slotted Liner in a Producing Oil Well[1]

Part 3 (Concluded)

By FRANK G. MILLER

Assistant Petroleum Engineer, U. S. Bureau of Mines, Petroleum and Natural Gas Division, San Francisco, California

IT may be regrettable that some of the experimental flow rates were rapid enough to permit partly turbulent flow in the sand just outside the slots, even though the flow was wholly viscous in the main sand body for all test rates, as the intercepts on the pressure axes of Figs. 10 and 11 indicate experimental losses that include an unknown loss due to turbulence. The formation of a sand bridge, however, that causes an effective positive pressure loss probably would induce turbulence at lower rates of flow because of the unusually tight packing of the sand grains of the bridge. It is noteworthy that the turbulence in the sand just outside the slots did not become fully developed at any of the test rates; that is, the head loss between tap 7 (Fig. 3) and the well wall was in all instances proportional to the flow rate raised to some power less than 2. This exponent was determined from the curves of Fig. 9; for slots A, B, C, and F it was 1.44 and for slot G it was 1.82. Nevertheless the experimental total losses determined with the flow of fluid-through-sand apparatus are somewhat greater than would be expected in the field under similar conditions if the flow is assumed to be wholly viscous in the sand in the immediate vicinity of the liner wall of a producing oil well. The results presented in Table 3, therefore, should be applied and interpreted with caution.

Figs. 10 and 11 show no positive experimental loss for slots B and C, and Table 2, which lists the convergence losses for the corresponding copper strips tested in the electrical model, shows that the use of strips B and C resulted in lower convergence losses than any of the other strips tested. In the electrical model the conducting medium was present and uniform to the well wall, so that there was an electrical resistance in the space between the well wall and any short distance from it regardless of the strip being tested. The sand evidently bridged the slots in the fluid flow experiments, and if it is assumed that the bridge was in the form of an arch it will not be difficult to conceive of a space between the arch and the slot being devoid of sand. The results of the tests given herein might suggest that the arch radius, or distance between the slot and the arch, increases with the slot width, provided, of course, that the same sand is considered in conjunction with all slots. The pressure drop between the slot and the arch radius would be small compared with the pressure drop across the same space if it had been filled with sand. It may be conceived, also, that the pressure drop between some point slightly beyond the arch and the well wall would be small compared to that between this point and the well wall, with the whole space under consideration filled with sand, even though the sand at the arch would have a lower permeability than that at some distance beyond the arch. On the other hand, it might be concluded that the difference in permeability between the sand just outside a slot and that of the main sand body may be positive or negative, depending on the factors influencing the formation of the bridge, which doubtless include slot dimensions and grain size distribution of original sand.

The foregoing theoretical considerations suggest that it would be possible for no additional pressure drop, caused by either convergence or arching, to become manifest in the vicinity of the well wall providing wide enough slots were used. As no positive intercepts, corresponding to slots B and C (the widest slots for which there are curves) are cut off on the pressure axes of Figs. 12 and 13, the experimental results substantiate the theory.

According to Coberly's[7] rule, a slot with a width equal to twice the grain size at the 10 percentile (obtained from sieve analysis curve) of the sand will prevent entry of sand into a well. Apparently no stable bridge would be formed if any wider slot were used. The 10 percentile of the test sand used in the experiments reported herein was 0.0165 in. (see Fig. 5), so that the widest slot that would prevent sand entry into the experimental well apparently would be 0.033 in. The widest slots used in the tests were 0.032 in. wide (slots B and C). An attempt was made, however, to test a slot 0.040 in. wide with the same sand, but this slot would not hold back the sand.

The results of the tests on all the slots as listed in Table 3 show that the additional pressure loss due to bridging increases as the slot width decreases for slots of the same length. It appears that if for one rate of flow the additional pressure loss due to bridging were plotted against width of slot (slots of the same length) the resulting curve would show that small changes in slot width correspond to relatively large changes in pressure loss.

A study of the experimental electrical and fluid flow systems reveals that the outer limit of the region of slot (or copper strip) influence is indicated in any particular test by the abscissa of the point at which experimental data begin to deviate appreciably from the respective straight line in Figs. 10, 11, or 12 representing radial flow. As the experimental data do not deviate appreciably from any of the straight lines of Figs. 10, 11, and 12 until r_n/r_w is at least less than 3, the flow disturbance in the sand (or electrolyte) caused by any of the slots (or copper strips) was within an annular space defined by the wall of the well and an imaginary cylinder having a radius equal to three times the well radius and having its axis coincident with the well axis.

Conclusions

This paper represents the results of an experimental investigation designed to determine the effect of the sizes of slot used in a slotted liner on the pressure gradient in the vicinity of the

A photograph and biographical sketch of the writer can be found on page 109 of the September issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

[1]Part of a more detailed thesis submitted to the University of California in partial fulfillment of the requirements for the degree of master of science in mechanical engineering. This paper also appeared as T. P. No. 1222 in A.I.M.E. *Petroleum Technology*, August, 1940.

[7]"Some Considerations in the Selection and Installation of Gravel Pack for Oil Wells," by C. J. Coberly and E. M. Wagner. Tech. Pub. 960, *Petroleum Technology*, Am. Inst. Min. and Met. Eng., August, 1938, p. 1.

wall of a producing oil well. Attention was directed to a study of the flow conditions about a single slot in each test as the flow conditions about all other slots of a liner were assumed to be similar.

The pressure gradient in the vicinity of a liner was predicted to be affected by three flow restrictions (whose relative influences could be evaluated) causing three additive pressure losses, the sum of which would indicate the total energy loss resulting from the use of a slotted liner. The three losses may be summarized as follows: (1) loss due to bridging of sand over slot, (2) convergence loss, and (3) slot loss. To evaluate these losses experiments were performed on a fluid flow-through-sand apparatus and on an electrolytic conduction model, both of which were designed to simulate the conditions prevailing about an actual slotted liner in a producing oil well. Only the effect of certain rectangular slots was measured.

The most pertinent results of the investigation follow:

(1) The additional pressure loss resulting from the formation of a sand bridge over a rectangular slot becomes small, nil, or even negative if the slot width used is equivalent to at least twice the grain size at the 10 percentile of the sand, taken from its sieve analysis curve. In any event, no material advantage is indicated if wider slots are used. It is quite important, however, that the width of slot be no smaller, as the pressure loss resulting from the bridge increases markedly when the slot width is reduced. In field practice, therefore, an attempt should be made to use slots whose widths are limited only by the possibility of sand entry into the well.

(2) The additional pressure loss resulting from the convergence of the streamlines, or their crowding in the sand near a slot decreases as the slot length is increased. The theoretical limiting length of a slot is the oil-bearing sand thickness. The experimental results show that the additional pressure loss per unit rate of flow due to a slot of this length is about one-third the loss for a slot of the same width but only one-half the length, placed so that its center is midway between the upper and lower horizons defining the oil-bearing sand, if the effect of bridging is neglected. An appreciable advantage may be had, therefore, by increasing the length of the slots, which should be limited only by strength requirements of the liner. Increasing the width of the slots without increasing the length does not reduce the convergence loss greatly.

(3) The pressure loss due to the slots, alone, which is similar to the pressure drop across an orifice in pipeline flow of fluids, is small compared with the corresponding loss that would occur in the sand near the slot.

(4) The experimental results suggest that most slots interfere with the normal flow conditions about a well within a region having the well wall as its inner boundary and an imaginary cylinder, concentric to the well, having a radius not exceeding three times the well radius, as its outer boundary.

(5) The apparatus and experimental technic described in this report would be adaptable to further

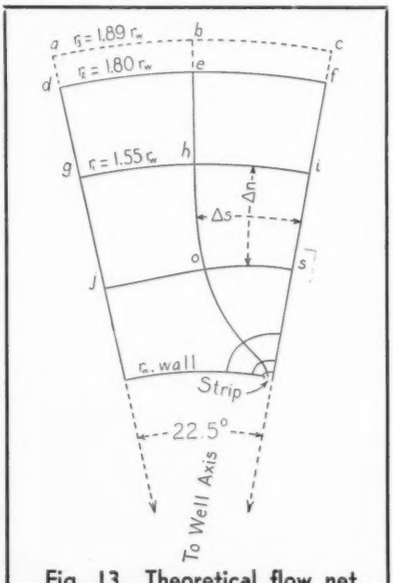

Fig. 13. Theoretical flow net for copper strip B

studies pertaining to the effect of a slotted or other type of perforated liner on the pressure gradient in the vicinity of the wall of a producing oil well. For example, the effect of the geometrical shapes of perforations and their pattern in the liner could be investigated, as only rectangular slots were considered in the study reported.

Appendix

A graphic method for solving two-dimensional flow problems concerning slots. A graphic method[8] for solving certain types of flow problems will be described briefly and applied by showing that the results pertaining to two-dimensional flow in the electrolytic conduction model could have been predicted successfully.

Detailed solutions of problems involving the viscous steady-state two-dimensional flow of homogeneous liquids of known viscosity through uniform and isotropic sands of known permeability may be obtained by graphic means without resorting to experiment or rigorous mathematical analysis, providing the geometry of the systems and certain boundary conditions are given. A unique and properly constructed potential and streamline network composes the solution of any of these problems. This flow net can be used to show potential distribution and to compute the value of the ratio of the total potential drop across the boundaries of a system to the total flux. As viscous flow is specified, Darcy's law is valid so that the potential drop-flux ratio can be used to compute the flux corresponding to any given potential drop, and the ratio is applicable in comparing flow systems of general likeness. The network pertaining to any particular fluid-flow system of the foregoing type is identical to the network of a geometrically similar electrical flow system, provided that Ohm's law describes the electrical current flow and that the medium conducting the current is isotropic.

If an incompressible fluid is flowing two-dimensionally through a porous medium in a steady-state condition the equation of continuity is:

$$\frac{\gamma u}{\gamma x} + \frac{\gamma v}{\gamma y} = 0. \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

In this equation u and v are components of the bulk discharge velocity in the directions of x and y coördinate axes, respectively.

Providing the viscous flow is in horizontal planes, Darcy's law for this system may be written as:

$$u = -\frac{k}{\mu}\frac{\gamma P}{\gamma x},$$

$$v = -\frac{k}{\mu}\frac{\gamma P}{\gamma y}, \quad . \quad . \quad . \quad . \quad (11)$$

where k, the permeability of the porous medium, is assumed to be uniform for all directions of flow, μ is the fluid viscosity, and P is the fluid pressure. A combination of equations (10) and (11) yields the two-dimensional equation of Laplace:

$$\frac{\gamma^2 P}{\gamma x^2} - \frac{\gamma^2 P}{\gamma y^2} = 0. \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Equation (12) represents the two orthogonal families of curves, termed the streamlines and the equipotentials, which compose a flow net. The two-dimensional equation of Laplace, however, arises in other physical problems. For example, the basic differential equation for a two-dimensional electric flow system could be obtained by replacing P (pressure) by E (voltage) in equation (12). Furthermore, iden-

[8]For a complete description and a summary of suggestions regarding the graphic method of analysis see: "Seepage Through Dams," by A. Casagrande, Harvard University Publications from the Graduate School of Engineering, 1936-37, No. 209, Soil Mechanics Series No. 5.

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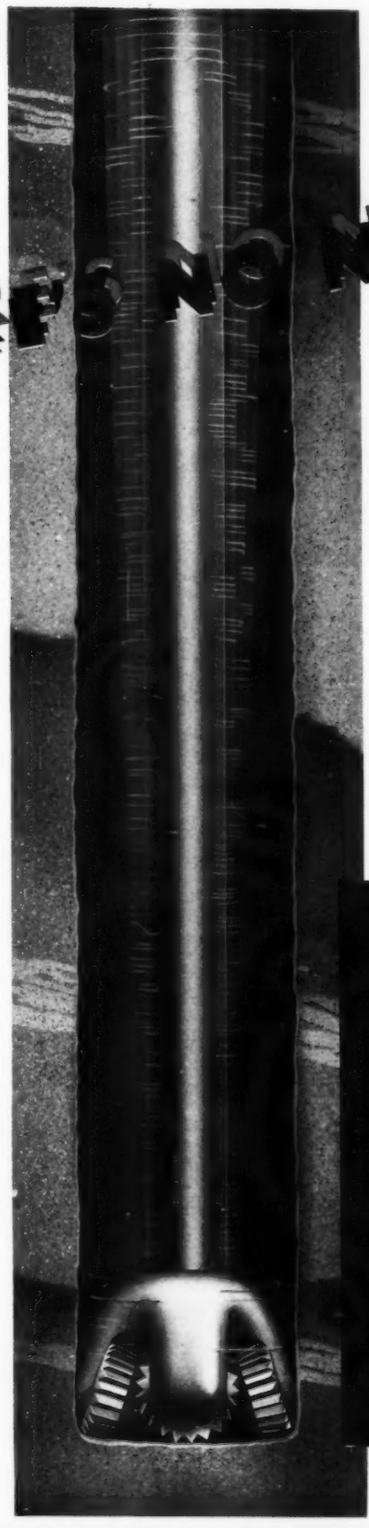

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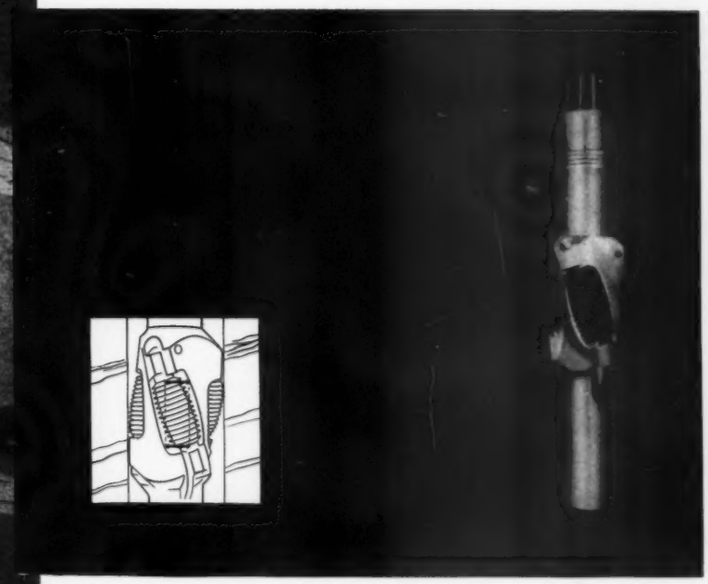

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tical flow nets result for corresponding electric and fluid-flow systems.

Analytic solutions of equation (12) are possible in many instances, but certain properties of streamlines (or current lines) and equipressure lines (or lines of equal electric potential) permit a graphic solution to be obtained without previous knowledge of the equations of the curves making up the flow net.

Briefly, the requirements that must be satisfied by the graphic solution, which is a flow net drawn by trial and error, are:

1. Flow lines (or current lines) to be perpendicular to equipotential boundaries.

2. Solid boundaries to form limiting streamlines for fluid flow net. Insulated boundaries to form limiting current lines for electrical flow net.

3. Flow lines and equipotentials to be perpendicular at their points of intersection.

4. Flow lines and equipotentials to form a network of curvilinear squares.[9]

The graphic method has been employed in obtaining the flow net for copper strip B shown in Fig. 13. The ratio of the strip width to the "well" diameter is 0.020.

Only one-half of the 45-deg. section is shown, as the net would be symmetrical about the center line *cfis* drawn through the strip. The surface of the strip was taken as the inner equipotential boundary, and the outer equipotential boundary was taken arbitrarily as a circle at a distance of 1.8 times the well radius from the "well" axis. The streamline (or current line) *beho* divides the net into two flow tubes so that four tubes, each carrying an equal flux, would be present if a 45-deg. section is considered.

The flow would be radial beyond the equipotential line *ghi* ($r_1 = 1.55\ r_w$) as it was found to be an arc of a circle centered at the well axis. As the outer equipotential boundary ($r_2 = 1.80\ r_w$) was taken arbitrarily (but beyond the region of strip influence), the adjacent rectangles may not be curvilinear squares. The next equipotential beyond *ghi* that forms curvilinear squares is designated by dotted line *abc* ($r_3 = 1.89\ r_w$) in the figure. Hence the potential differences represented by the distances *gd*, *he*, or *if* will be determined as a proportion of the potential differences represented by *ga*, *hb*, or *ic* across the outermost curvilinear squares. As the flow is radial beyond *ghi*, the potential beyond varies with the logarithm of the distance from r_1. The desired proportion is, therefore:

$$\left(\log \frac{r_2}{r_1}\right) \Big/ \left(\log \frac{r_3}{r_1}\right) = 0.75$$

Thus, inspection of the plot will indicate its being divided into 5.75 increments of potential, within the arbitrarily chosen outer boundary, as the distances between adjacent equipotential lines bounding curvilinear squares represent a constant fraction of the total drop.

To obtain an equation for the total flux relating to a fluid-flow system, consider the flow parallel to the plane of the paper through only one curvilinear square, for example *hios*, and then apply Darcy's law. Let Q in the equation be the total flux, ΔP the pressure difference across the limiting equipotential boundaries, k the permeability of the porous medium, μ the fluid viscosity, N the thickness of the section perpendicular to the plane of the paper, Δn the mean length of the square, Δs the mean width of the square, ξ the number of flow tubes in the net and η the number of increments of potential. Then, on substituting, the equation becomes:

$$\frac{Q}{\xi(N\Delta s)} = \frac{k}{\mu}\left(\frac{\Delta P}{\eta}\right)\frac{1}{\Delta n},$$

but for a curvilinear square $\Delta n = \Delta s$, so that:

$$Q = N\frac{k}{\mu}\left(\frac{\xi}{\eta}\right)\Delta P. \quad . \quad . \quad . \quad (13)$$

Equation (13) for a corresponding electrical flow system would be:

$$I = \frac{N}{\sigma}\left(\frac{\xi}{\eta}\right)\Delta E, \quad . \quad . \quad . \quad . \quad (14)$$

where I is the current flowing, σ the specific resistance of the conductor composing the flow section, and ΔE the electric potential across the boundaries.

The ratio $\frac{\xi}{\eta}$ is termed the shape factor and for the figure shown is $\left(\frac{4}{5.75}\right)$ or 0.70 for copper strip B, considering a 45-deg. sector.

Shape factors were determined similarly for two other copper strips, A and C. The ratio of strip width to "well" diameter for A was 0.01 and the corresponding ratio for C was 0.064. The shape factors determined graphically were 0.64 and 0.76, respectively. It will be realized that the shape factor is inversely proportional to the potential drop-flux ratio and is better suited than this ratio for comparing flow systems of general likeness.

The method used in determining shape factors from experimental data for strips A, B, and C (the two-dimensional flow strips) follows. The shape factors determined from experimental results will be compared with those obtained graphically. As the flow nets determined by the trial and error process were drawn for an outer equipotential boundary at a radial distance equal to 1.8 times the well radius the voltage drop per unit rate of current flow corresponding to $\frac{r_n}{r_w} = 1.8$ is taken from the experimental curves of Fig. 12 for strips A, B, and C; the values are found to be 21.9, 19.5, and 18.0 v. per amp., respectively, as shown by dotted lines in the lower left corner of the graph. Each of these values is substituted in equation (14), which may be written:

$$\left(\frac{\xi}{\eta}\right) = \left(\frac{I}{\Delta E}\right)\frac{\sigma}{N}.$$

For strip B:

$$\left(\frac{\xi}{\eta}\right) = \left(\frac{1}{19.5}\right)\frac{6.88}{0.5} = 0.706,$$

where 0.5 is the considered depth of the electrolyte in ft. The shape factor for strip B determined by the graphical method was 0.70. Similarly the shape factors for strips A and C from experiments were found to be 0.643 and 0.765, respectively; whereas the shape factors for strips A and C from their flow nets constructed by the graphic method were 0.64 and 0.76, respectively.

It may be of interest to note that the experimental points in Fig. 12 relating to two-dimensional flow do not deviate from the straight lines representing radial flow at least until $\frac{r_n}{r_w}$ is less than 1.8.

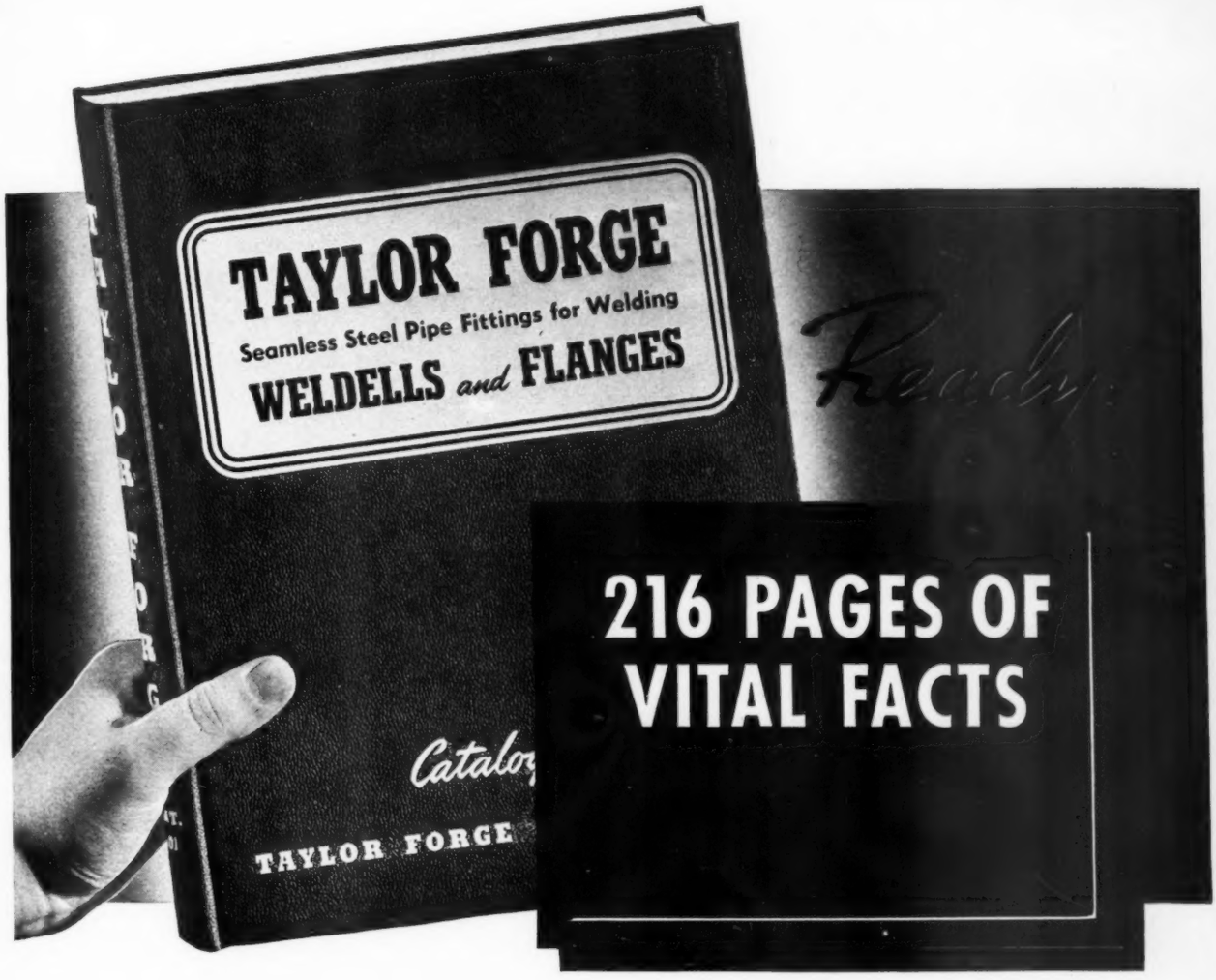
Acknowledgments

The author is indebted to the Department of Mechanical Engineering of the University of California, in whose laboratories the experiments were conducted.

Grateful acknowledgment for many valuable suggestions offered during the course of this investigation is made to Prof. M. P. O'Brien, chairman of the Department of Mechanical Engineering, University of California, under whose direction this study was initiated.

The author wishes to express his thanks to R. A. Cattell, chief engineer, and H. C. Fowler, both of the Washington, D. C., office, Petroleum and Natural Gas Division, U. S. Bureau of Mines, for many helpful suggestions regarding the preparation of this report for publication and to the following members of the Bureau of Mines in the field who read and constructively criticized manuscript copies of the report: C. P. Bowie, H. C. Miller, G. B. Shea, R. V. Higgins, G. L. Gates, E. S. Burnett, Gustav Wade, Ralph H. Espach, and Kenneth Eilerts.

[9] A curvilinear square is a plane figure approximating a regular square in shape, having four sides, four right angles, and the mean distances between opposite sides equal, even though the sides be unequal in length and two or more of them be curved.



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Recommended Practices in Removing Drillable Metals

Bit design, weight on bit, table speed, pump pressure, and mud — all are important factors in new drilling technique

By RALPH C. GRAHAM
District Engineer, Security Engineering Company, Inc.

RALPH C. GRAHAM

graduated from Missouri School of Mines in 1931, receiving his degree in petroleum engineering—Was first affiliated with The Texas Company in Oklahoma, later employed by The Carter Oil Company in 1934 and engaged in various drilling and producing work in Oklahoma—Transferred to Illinois in 1938 and was instrumental in developing the use of drillable casing in multiple-zone completions of the Loudon pool—Resigned in 1939 as district engineer to enter the employ of The Security Engineering Company, Inc.—After a year in the main office of the company at Whittier, California, was transferred to the position of district engineer in the Houston, Texas, office.

DRILLABLE METAL has been employed in oil well completions for a period of several years and during that time the installations have been numerous and varied. The use of drillable metal is based upon its susceptibility to easy removal by normal drilling operations. Many operators have had occasion to remove the metal by drilling and have found that the most satisfactory results are obtained if certain practices are followed. Tabulations of typical drilling data involved have been compiled and are listed herewith together with the various phases to be considered when drilling is contemplated.

Bit Design

It has been found that the piloted type drilling bits of the drag tooth design are best suited for removing the drillable pipe (Fig. 1). The pilot stabilizes the bit, prevents the tendency to sidetrack, and destroys "bridges" inside the pipe to be removed. The cutting edges of the pilot should be sufficiently sharp to cut through cement or formation bridges within the pipe. The drag blades should have a rake of approximately 20 deg. and a clearance angle of about 10 deg. for best performance. (Fig. 2). Angles larger than this cause the blades to "dig in" and remove larger pieces than is best suited for easy displacement. The diameter of the cutting blade of the pilot should be within ¼ in. of the inside diameter of the pipe to be destroyed and the diameter of the main cutting blades should be of the proper size to permit free rotation within the casing in the well. The bit should be designed to provide adequate circulation with sufficient velocity to carry the cuttings away from the bit. It is advantageous to circulate freely for a few minutes before each new drill pipe connection is made.

Regular type rock bits are not suitable for removal of drillable metal as they depend upon a tearing and crushing action for penetration. It is essential that drillable metals be removed by a shearing action similar to the machining action in lathe operation. Rock bits have been used satisfactorily for this type of destruction although the rates of penetration are slower than with the drag bit type. A recent record of a well having an installation of this type denoted that 28 ft. of drillable tailpipe, cemented-in solidly, was removed with two rock bits at an average rate of 2 ft. per hr. These cases are exceptional, however, and a careful analysis of the well conditions should be made before work of this type is attempted. It should be pointed out again that the drag tooth type is usually far superior in drilling rates and should be given first consideration.

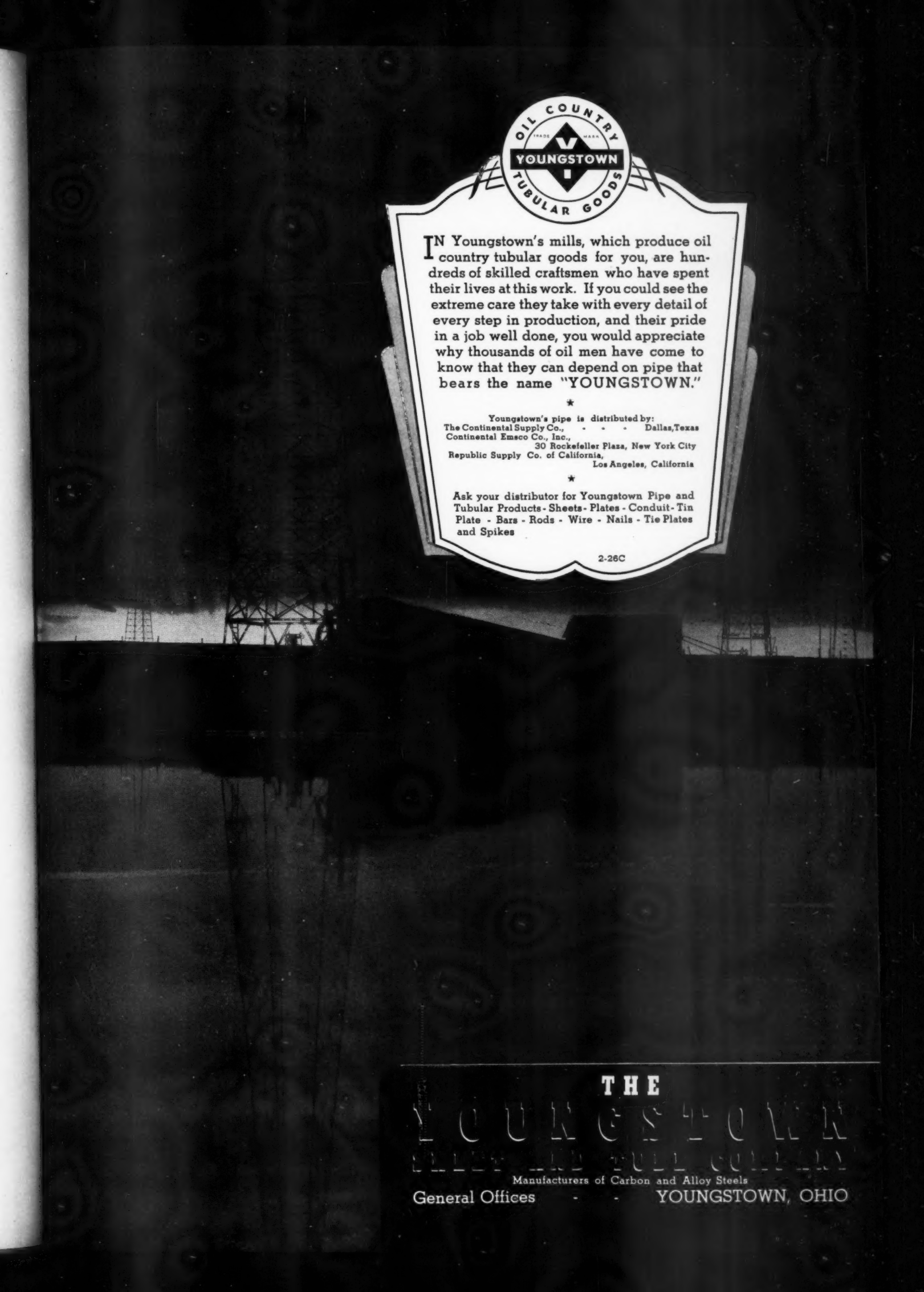
Weight on the Bit

The drilling weight found to be most satisfactory has been about 2000 lb. This will approximate from ½ to 1½ points of weight on the weight indicator, depending on the number and size of the lines over the crown block. To obtain best results, it is imperative that the weight indicator be sensitive enough to record small variations in weight. The underlying principle behind weight control in metal removal is to hold up the weight sufficiently so that on each rotation the bit engages only a small portion of the circumferential ring of the drillable metal and thereby cuts small chips that are easily displaced with the mud stream. Fig. 3 illustrates actual cuttings from a well when the weight was controlled to one point or less. If too much weight is applied to the bit, the blades tend to "dig in" and cut long ribbons of the metal. This is caused by the weight being sufficiently great to permit the blades to make a continuous gouging cut rather than to procure small chips. Fig. 4 shows typical ribbons resulting from an excess of weight. Cuttings of this type are not easily removed and could cause the drill pipe to freeze or the bit to plug.

When it is impossible to determine the bit weight accurately, a check of the cuttings left on the mud screen from the mud discharge should be made. Careful observation of these cuttings will supply the driller with sufficient information to control the weight and speed. Regardless of the accuracy of the weight indicator, this check should be made as a matter of precaution. It is always necessary to have a mud screen or some other device to catch the cuttings in order to prevent them from being recirculated. Recirculation of cuttings would eventually fill the hole with more material than the mud stream could handle and might even cause the bit to plug. Excessive wear on the mud pumps would also result from handling the metal cuttings.

Rotary Table Speed

Rotary table speeds ranging from 50 to 125 r.p.m. have been used satisfactorily. Speeds from 100 to 125 r.p.m., however, seem to be preferred as this rate coupled with light weight on the bit gives the cutting blades more revolutions per foot of penetration, which results in smaller chips. Prior to actual field operation, experimental work was undertaken with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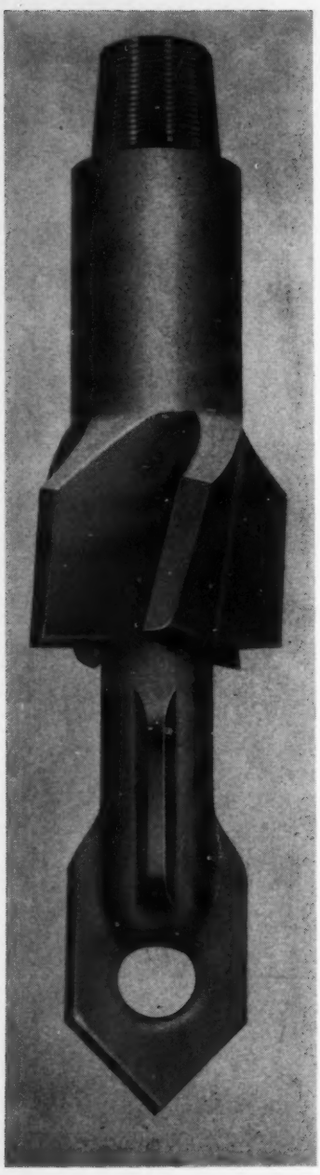

Fig. 1. Piloted-type drilling bits of drag tooth design are best suited for removing drillable pipe

shop equipment designed to duplicate field drilling. These tests indicated the speeds to be desired. Some operators have used regular tubing as a drill string to remove liners set inside steel casing and slower speeds have been used in these instances. High rates of speed will subject the tubing to excessive torque, and difficulty is then encountered in "breaking out" the tubing when changing bits or coming out of the hole after the drill-up is completed. Rates from 50 to 85 r.p.m. with ½ point of weight seem to be best suited for drilling when tubing is used.

Pump Pressures

Pump pressures employed have an extensive range as is shown in the accompanying tables. It appears that any pressure that is adequate for proper mud circulation is suitable. Pumps handling large volumes with correspondingly high pressures obviously will remove the chips more readily and will give the same beneficial results that are obtained in regular drilling. These high pressures and volumes are not mandatory, however, but precautions should be taken to see that normal returns are being obtained and that some of the chips are not being left in the hole to be redrilled or to form bridges in the hole.

Mud Viscosity and Weight

Drillable metal has approximately the same specific gravity as shale so that any mud viscosity that is suitable for removing the shale cuttings will remove the metal chips readily. Mud viscosities of 30 sec. A.P.I. or above are recommended but lesser viscosities will not be a hindrance. Clear water is not recommended for use. In old wells in which the sand pressures are low and the use of mud would be detrimental to future producing conditions, heavy oil can be used as a circulating medium.

Control of mud weight has little importance and the same mud weight used in drilling the well can be used with satisfactory results.

Discussion of Tables

Four tabulations are presented to show average drilling rates for cemented and uncemented liners in the Gulf Coast and California. These records were chosen to show as wide a divergence as possible in liner sizes, well depths, etc., so that their application to future work could be easily compared. These tables list not only liners that were drilled intentionally but also many where other methods of removal, such as pulling, failed and drilling was resorted to in order to regain the full gauge hole.

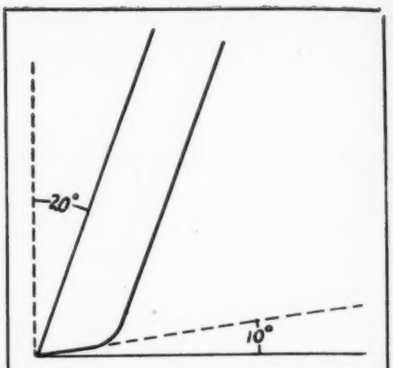

Fig. 2. Drag blades of the drilling bit should have a rake of about 20 deg. and a clearance angle of about 10 deg.

The following facts are readily noticeable in studying the tables: (1) Very small chips resulted when high rotating speeds and light weight were employed. This has been previously discussed and is to be expected. (2) Faster drilling time occurred when it was not necessary to drill-up packers, liner hangers, or other accessories be-

Fig. 3. Cuttings from a well when the weight on the bit was one point or less

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- A. O. Smith is one of the *major* manufacturers of:
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fore reaching the liner. This is a normal expectation, and although tables are not presented to show average drilling rates for accessories fabricated from drillable metal, the average rate of removal has been found to be 2 to 3 ft. per hr. (3) Low penetration rates were evident when tubing was used as the drill string. This has previously been discussed, and these low rates usually resulted from operators reducing the drilling speed to save their tubing. (4) Cemented liners show an average rate of removal lower than uncemented liners, and this, too, is to be expected as the bit cannot remove the liner any faster than it can remove the material surrounding the liner. A slightly lower average rate is obtained, therefore, when it is necessary to remove cement with the liner.

No direct relationship could be traced in efforts to correlate the effects of mud weight, mud viscosity, pump pressure, or table speed to the rate of removal. It is logical to assume that small-diameter liners should drill-up faster when confined in small-diameter holes, but nevertheless, it can be observed that some of the best drilling speeds were obtained when comparatively large diameter liners were set in a large annulus.

This, then, leads to the conclusion that all other things being equal, the human element is the deciding factor in determining the amount of success obtained. This is particularly true when long liners require changing of bits and drillers endeavor to make as much hole as possible before coming out to change bits. Dull bits with the main cutting blades reduced in diameter by wear can enter the inside of the liner. This will tend to bell out the liner, and the bit will cut along the walls inside the liner. This will leave a thin outer shell to be cut and removed by the next full gauge bit or possibly produce large thin pieces that will break off and become loose in the hole. Occasionally, these pieces are removed when changing bits and are nearly always found to be wrapped around the drill collar or drill pipe. This can be prevented by observing the chips returning on the mud screen. Chips obtained when excessive weight causes the bit to bell the liner are readily detectable as they are thinner and usually of larger size than a correctly cut chip. The variance in

TABLE 1
Removal of Drillable Liners (Uncemented)
California

Hole depth, ft.	Liner length, ft.	Liner size, in.	Hole size, in.	Avg. pump pressure, lb. per sq. in.	Mud viscosity, sec.	Mud wt., lb. per cu. ft.	Table speed, r.p.m.	Bit wt., points	No. bits used	Footage per bit	Drilling time, hr.	Footage per hr.	Remarks*
1970	30	4¾	6½	.....	.....	75	65	.....	1	30	1.5	20.0	Liner used in formation test. Drilled with portable rig.
3823	201	5	.....	400	.....	65	85	1–2	1	201	13.0	15.5	Included adapter.
4225	624	4¾	9½	.....	.....	65	90	1–2	6	104	58.0	10.8	Included slip-type liner hanger.
5930	75	4¾	7⅞	.....	28	70	100	1	1	75	10.0	7.5	Included slip-type liner hanger.
6275	80	5½	.....	500	30	75	75	1–2	1	80	8.0	10.0	Included adapter.
6280	67	6⅝	8½	.....	35	76	75	1½	1	67	5.0	13.4	Drilled 60 ft. of cement after liner removed. Included adapter.
6300	158	6⅝	8½	.....	34	75	100	1	2	79	26.0	6.0	Included adapter.
6431	91	5½	8⅝	.....	.....	80	90	1–2	1	91	9.0	9.1	Included adapter. Drilled 2 ft. new hole below liner.
6500	186	4¾	7⅝	750	.....	78	105	1	2	93	18.0	10.5	Pulled 30 ft. prior to drilling.
6715	50	6⅝	8½	450	.....	78	125	1	1	50	7.0	7.0	Used small pumps.
6735	65	6⅝	8¾	650	.....	72	110	1	1	65	10.0	6.5	Pulled liner hanger and 17 ft. of liner before drilling.
6859	60	6⅝	.....	.....	.....	73	85	1–2	1	60	4.5	13.4	Drillable liner on lower end of steel liner.
7630	100	5	8½	700	.....	73	130	½	1	100	19.0	5.0	Very small chips.
7724	124	6⅝	.....	.....	.....	77	85	1	4	31	28.0	4.5	Included slip-type liner hanger.
7850	81	5¾	.....	.....	.....	68	80	½–2	2	40	5.0	16.2	Reduced I.D. section below steel liner.
7940	197	5½	.....	1500	40	64	150	½	1	197	23.0	8.5	Very small chips.
8112	193	4¾	8½	1600	.....	80	90	½	2	97	32.0	6.0	
8650	80	6⅝	8½	1000	34	78	225	1	1	80	8.0	10.0	Included slip-type liner hanger. Very small chips.
9227	246	5	7⅝	.....	45	.....	90	1	2	123	20.0	12.0	Sidetracked 350 ft. left in hole.
9653	263	4¾	8½	1500	32	78	85	¼	2	131	52.0	5.1	
9715	100	5½	8½	1200	32	75	100	1	1	100	18.0	5.5	
10,060	19	4¾	8½	1100	32	85	150	½	1	19	4.0	5.0	Very small chips.
10,733	46	4¾	7⅞	.....	.....	70	80	1–2	1	46	2.5	18.4	Included adapter.
Totals	3136								37		381.5		
Averages	136									86		8.2	

*All accessories fabricated from drillable metal.

TABLE 2
Removal of Drillable Liners (Cemented)
California

Hole depth, ft.	Liner length, ft.	Liner size, in.	Hole size, in.	Avg. pump pressure, lb. per sq. in.	Mud viscosity, sec.	Mud wt., lb. per cu. ft.	Table speed, r.p.m.	Bit wt., points	No. bits used	Footage per bit	Drilling time, hr.	Footage per hr.	Remarks*
4647	195	5¾	8½	.....	.....	72	80	1–3	5	39	55.5	3.5	Included adapter and cement basket.
6244	424	6⅝	.....	.....	.....	75	90	1–2	3	141	48.0	8.8	Included slip-type liner hanger, cement collar, and basket.
6420	60	6⅝	7⅞	650	.....	78	120	1	1	60	7.0	8.5	Included adapter.
7000	65	6⅝	8½	700	.....	77	80	½	2	33	12.0	5.5	Included adapter and three centralizers.
7362	50	5¾	7⅝	800	35	80	115	1	1	50	9.0	5.5	
7501	66	5¾	7⅞	.....	.....	80	80	1	1	66	8.5	7.8	Included adapter, cement collar, and basket.
7656	50	5	8½	1250	.....	72	125	1	1	50	9.0	5.5	
8264	121	5	.....	.....	.....	65	90	1	2	60	13.0	9.3	Included adapter.
10,300	646	4¾	.....	.....	.....	67	90	1	6	108	67.0	9.6	Included slip-type liner hanger and cement collar.
11,590	97	5	.....	1600	37	80	125	½	1	97	16.0	6.0	Included adapter.
11,608	275	5¾	8⅝	1800	35	76	100	1–2	2	138	35.0	7.9	Included adapter.
Totals	2049								25		280.0		
Averages	186									82		7.3	

*All accessories fabricated from drillable metal.

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EXAMPLE: *Right, four Cummins Dependable Diesels are used on this rig drilling a 10,000-ft. test well near Lake Charles, Louisiana.*

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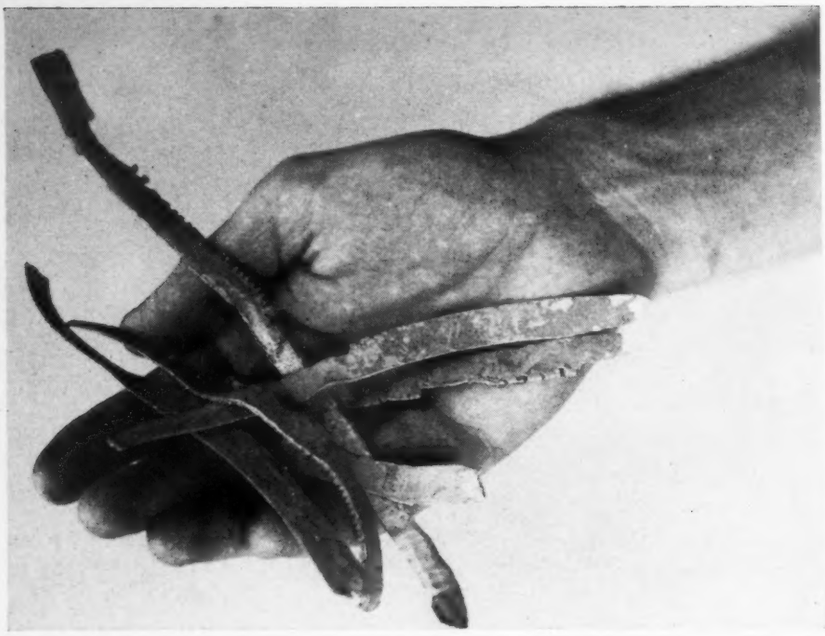


Fig. 4. If weight on bit is excessive, ribbons of this type result. Such cuttings are not so easily removed

chip characteristics is quite noticeable. Careful continual observation of the mud returns will disclose this condition, and a new bit should be run immediately.

The average footage per bit indicated in the tables is lower than the service to be normally expected as a number of the liners removed were short in length and the drilling was completed before the bit was dull.

Some of the drill-ups shown, particularly those for the Gulf Coast area, were "inside settings," that is, a drillable liner is set inside steel casing that has been set through the sand and gun-perforated. In this type of setting it is possible for the liner to become loose after the liner hanger or packer is drilled. Sufficient sand to freeze the entire liner may not have entered the annular space through the gun-perforations. Portions of the liner then would be free to rotate with the bit, and this spinning would defeat efforts to drill-up the liner. Records compiled to date show only one occurrence of this type, and in this case the main portion of the liner was pulled and salvaged. Situations of this type would not be expected when the liner had been left in the hole for a considerable length of time or when the liner extends into the open hole.

The methods discussed in the preceding paragraphs have dealt with removal by rotary methods. Cable-tool removal has also been employed successfully and has been discussed in a previous article[1].

[1] "Drilling and Completion Practices in Illinois Basin Involving Use of Lightweight Alloy Metal," by R. C. Graham, *The Petroleum Engineer*, May, 1940.

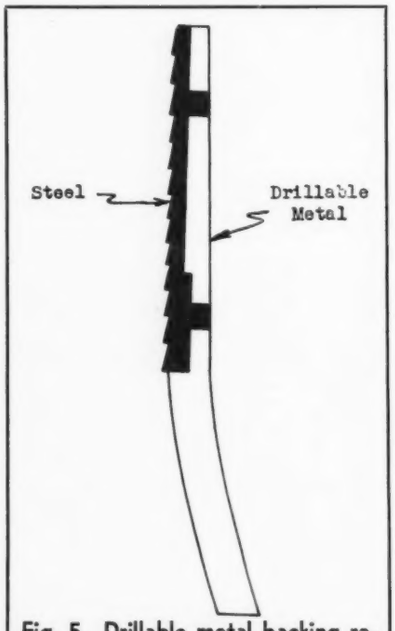


Fig. 5. Drillable metal backing reduces amount of steel required in drillable slips

One important point that should be emphasized concerns the use of steel in conjunction with drillable metal. Spring steel centralizers or other bulky accessories constructed of iron or steel should not be used with drillable metal if the drillability features are to be maintained. Equipment of this type will resist drilling in the same manner as if they were used alone, and drillable metal products cannot be expected to be removed with any degree of success if the bit periodically encounters iron or steel.

Certain parts of drillable accessories must, at times, be made of ferrous metals due to the requirement of higher physical strength for their proper operation. Accessories of this type should be designed with a minimum amount of steel or iron to preserve the drillability features.

One method that has been successfully employed in reducing the amount of steel in drillable slips is shown in Fig. 5. The drillable metal backing eliminates the amount of steel needed otherwise. The small amount of steel that is used to face the slips is case hardened and breaks up readily when drilled.

A continuous ring of steel formed by slips should also be avoided. Fig. 6 illustrates how the cutting blades will ride on a typical slip assembly of a regular type steel hanger. The blades are retarded and prevented in further progress by this ring. Fig. 7 shows how one manufacturer of drillable accessories constructs the slips to overcome this. The slips are made of case-hardened steel with drillable metal backs. They are spaced sufficiently far apart to permit the blades to penetrate downward into the softer drillable metal between the slips. Then, when the blades encounter the steel slips,

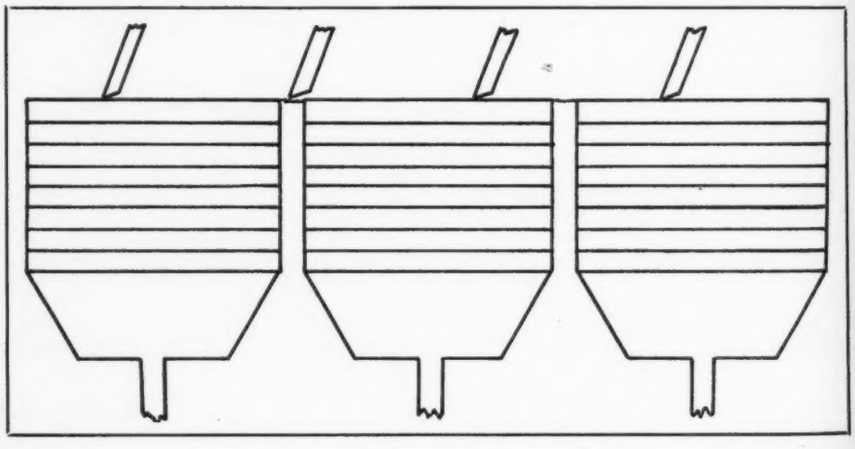
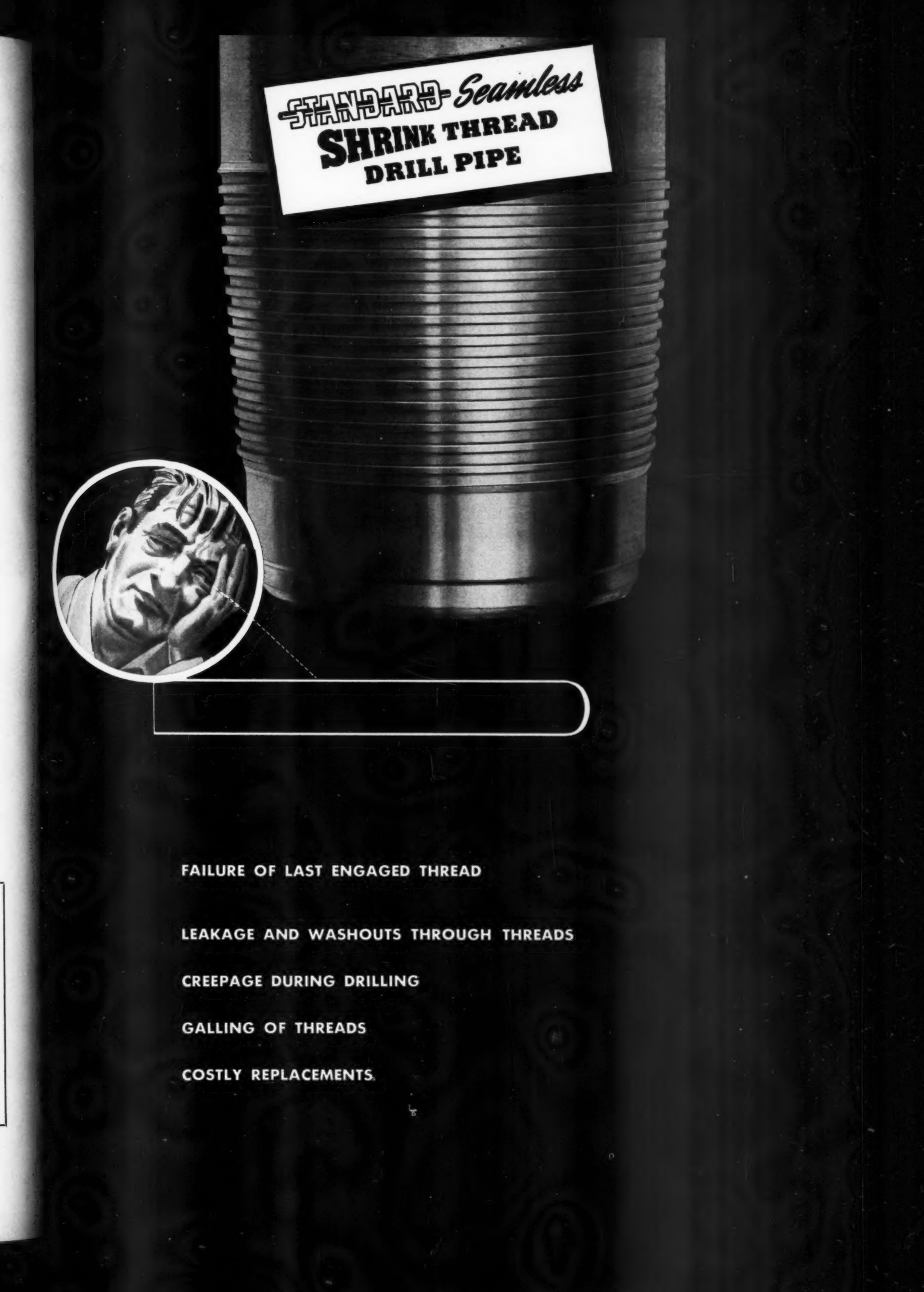


Fig. 6. A continuous ring of steel formed by slips should be avoided



FAILURE OF LAST ENGAGED THREAD

LEAKAGE AND WASHOUTS THROUGH THREADS

CREEPAGE DURING DRILLING

GALLING OF THREADS

COSTLY REPLACEMENTS

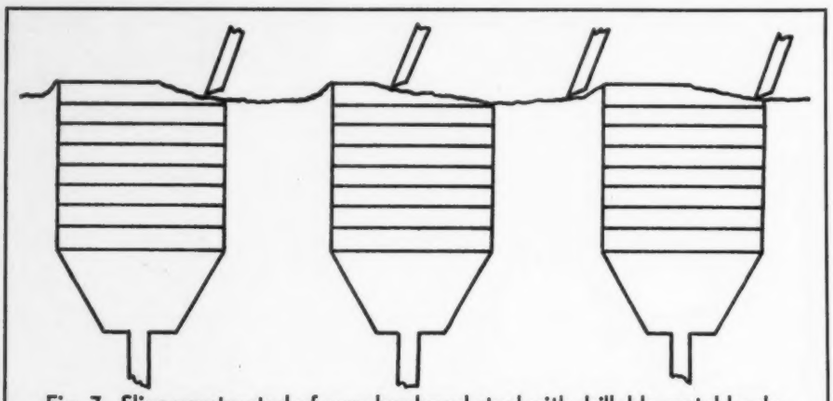


Fig. 7. Slips constructed of case-hardened steel with drillable metal backs, properly spaced, are easily drilled-up

they break off a small chip of the steel. This continues until all the steel is removed. This method of construction has been very successful and very little difference has been noted between drilling this portion of the accessory and the part that is composed entirely of drillable material.

Although this article is presented primarily to describe correct drilling technique for removing drillable metal by bits, the use of the wall scraper as a medium of removal should be mentioned. Wall scrapers have been used almost exclusively in the Illinois Basin for removal, apparently with good results. Cutting rates there have been approximately 4 ft. per hr.[2] An example of this type of removal elsewhere is best shown by the following example:

[2] "Multiple Sand Completions," paper presented by Bart De Laat at A.P.I. Eastern District Meeting, Columbus, Ohio, April 11-12, 1940.

A California operator desired to cut-out the lower 208 ft. of a 500-ft., 5¾-in. drillable liner set and cemented in a 7½-in. hole at a depth of approximately 9400 ft. Two sets of blades were employed to remove the 208 ft. in a drilling time of 31 hr. or at an average rate of 6.7 ft. per hr. Before starting to drill, approximately ½ hr. was employed in rotating the scraper to expand the blades properly to their full diameter. No trouble was encountered in removing the desired section of the liner, and the remaining portion was left in the hole and used in the new well completion.

It can be seen by the accompanying tables and the methods described that drillable metal removal has passed the experimental stage and with proper precaution and correct drilling technique, extremely gratifying savings can be obtained. The benefits of drillable metal are becoming more apparent each day to oil operators, and its use is being incorporated into a multiplicity of tools. A great stride has been taken in overcoming the operators' fear of cementing equipment in the hole, and future progress along this trend can be expected.

TABLE 3
Removal of Drillable Liners (Uncemented)
Gulf Coast

Hole depth, ft.	Liner length, ft.	Liner size, in.	Hole size, in.	Avg. pump pressure, lb. per sq. in.	Mud viscosity, sec.	Mud wt., lb. per gal.	Table speed, r.p.m.	Bit wt., points	No. bits used	Footage per bit	Drilling time, hr.	Footage per hr.	Remarks*
7800	25	4¾	7	.....	30	10.5	85	1	1	25	1.3	20.0	Included 2 ft. adapter. All of liner inside 7-in. O.D. steel casing.
7335	5	4¾	6	.....	30	9.0	75	1	1	5	1.0	5.0	Drilled up canvas wrap packer liner came loose, pulled and reran later.
8075	14	4¾	7	1400	.....	10.5	50	1	1	14	2.5	6.0	Included canvas wrap packer. All of liner inside 7-in. O.D. steel casing.
8930	78	3½	5	1300	.....	10.0	60	½	1	78	18.0	4.3	Included canvas wrap packer. Drilled with 2½-in. upset end tubing. All inside 5-in. O.D. steel casing.
8990	38	4	6	.....	28	10.5	50	½-1	1-¼	21	6.0	6.0	Included canvas wrap packer. All inside 6-in. O.D. steel casing.
Totals Averages	110 32								5¼	30	28.8	5.6	

*All accessories fabricated from drillable metal.

TABLE 4
Removal of Drillable Liners (Cemented)
Gulf Coast Area

Hole depth, ft.	Liner length, ft.	Liner size, in.	Hole size, in.	Aug. pump pressure, lb. per sq. in.	Mud viscosity, sec.	Mud wt., lb. per gal.	Table speed, r.p.m.	Bit wt., points	No. bits used	Footage per bit	Drilling time, hr.	Footage per hr.	Remarks*
5215	20	5	.....	.....	30	10.0	85	1	1	20	2.0	10.0	
5817	63	5	7 O.D.	950	36	9.5	90	1	2	31	15.0	4.7	Included cement retainer and canvas wrap packer all inside 7-in. O.D. casing.
6600	60	5	8⅝	1000	30	10.5	70	1	3	20	14.0	4.5	Drilling retarded by steel in the hole.
8158	63	5	8⅝	1250	38	10.0	100	1	1-½	42	12.0	5.2	Included canvas wrap packer.
8615	60	5	7 O.D.	900	28	9.5	100	½-1	1	60	10.0	6.0	Included canvas wrap packer all inside 7-in. O.D. casing.
8765	200	5	6½	900	30	9.5	100	½-1	4	50	32.0	6.3	Included canvas wrap packer.
8930	78	3½	5	1300	.....	9.8	60	½	1	78	18.0	4.3	Included canvas wrap packer. All inside 5-in. casing. Drilled with 2½-in. upset end tubing.
Totals Averages	544 78								13½	40	103.0	5.3	

*All accessories fabricated from drillable metal.

Coyote Lassoed by Gas Line

This coyote possibly didn't know he was in the Texas cow country or he would have been more wary even of a gas line.

The picture was taken by Henry Kerr (far right), district engineer, Oil Production Department, Arkansas Natural Gas Corporation, in the Alice field, Jim Wells County, Texas, after receiving a call from Ralph Crenshaw (immediate right), a gas-lift engineer with Wilson Supply Company.

Crenshaw was working on a well about 9:00 o'clock at night when he heard an explosion at a point about 200 yards away. Upon investigation he discovered that a 2-in. pressure line had blown in two and that the pipe had whipped around and wrapped itself about the neck of a wild coyote, killing it instantly. The pipe was looped so tightly it was impossible to extricate the coyote's head without straightening the pipe. Crenshaw called Kerr, who arrived on the scene about 10:30, and the picture was taken with the aid of flash bulbs.

A. P. I. 21st Annual Meeting, Chicago—Some of

E. E. Ambrosius, associate professor of mechanical engineering, University of Oklahoma, collaborated with W. H. Carson on a paper entitled: "Fluid Meter Research at The University of Oklahoma"

Harold M. Trimble, Phillips Petroleum Company, collaborated with K. C. Battenberg on a paper entitled: "Fuel Quality Requirements as Effected by Items of Engine Maintenance"

Robert E. Wilson, president, Pan American Petroleum and Transport Company, and adviser to the National Defense Commission, was a guest speaker

W. G. Lovell, General Motors Corporation, collaborated with T. A. Boyd on a paper entitled: "Trends in Automotive Design Match Evolution in Fuels"

J. C. Stirling, engineer, Stanolind Pipe Line Company, was presiding officer at the Thursday morning Production Group Session on Pipe Line Transportation Problems

E. R. Smoley, The Lummus Company, collaborated with J. E. Bogk and P. Ostergaard on a paper entitled: "The Naphtha Polyform and Gas Reversion Processes"

Robert B. Bossler, Brundred Oil Corporation, collaborated with Parke A. Dickey on a paper entitled: "Oil Recovery by Air Drive in the Venango Fields of Pennsylvania"

P. Ostergaard, Gulf Oil Corporation, collaborated with J. E. Bogk and E. R. Smoley on a paper entitled: "The Naphtha Polyform and Gas Reversion Processes"

H. H. James, E. I. du Pont de Nemours and Company, Inc., spoke on "Illustrated Field Observations of Paint Performance and Practices in Refineries"

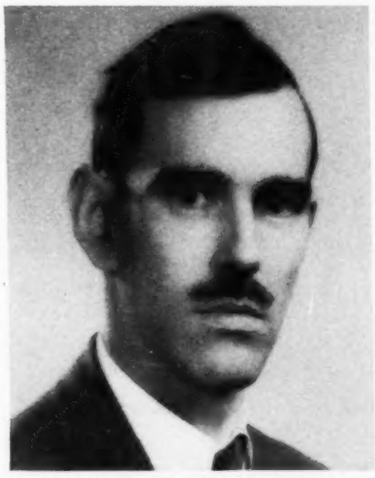
the Speakers, Committee Chairmen, Presiding Officers

Parke A. Dickey, Pennsylvania Topographical and Geological Survey, collaborated with Robert B. Bossler on a paper entitled: "Oil Recovery by Air Drive in the Venango Fields of Pennsylvania"

J. E. Bogk, Phillips Petroleum Company, collaborated with P. Ostergaard and E. R. Smoley on a paper entitled: "The Naphtha Polyform and Gas Reversion Processes"

George W. Hanneken, Standard Oil Company of Ohio, was presiding officer at one of the Refining Group sessions

H. W. Fletcher, Hughes Tool Company, chairman of the Correlating Committee on Gages and Gaging Practice



A. H. Schutte, The Lummus Company, spoke on "The Emulsion De-Oiling Process"

W. H. Carson, Dean, College of Engineering, University of Oklahoma, collaborated with E. E. Ambrosius on a paper entitled: "Fluid Meter Research at The University of Oklahoma"

Conger Reynolds, Standard Oil Company (Indiana), chairman of the Committee on Motor Fuels

John R. Suman, Humble Oil and Refining Company, chairman of the Committee on Standardization of Oil-Country Tubular Goods

T. A. Boyd, General Motors Corporation, collaborated with W. G. Lovell on a paper entitled: "Trends in Automotive Design Match Evolution in Fuels"

I. P. A. A. Meets in Dallas

Walter W. Trout, Lufkin Foundry and Machine Company, Lufkin, Texas

Dr. Robert E. Wilson, petroleum adviser to the National Defense Commission, reaffirms the petroleum industry's ability to fulfill all demands made upon it

Emby Kaye, vice-president, Distillate Engineering and Processes Company, Tulsa, Oklahoma

Chas. F. Roeser (left), president, Roeser & Pendleton; Ralph T. Zook (center), president, Sloan & Zook Company; and Paul G. Blazer, president, Ashland Oil & Refining Company, get a "line-up" on the day's program

James H. Tucker (left), and J. D. "Johnny" Best (right), both of Mission Manufacturing Company, and V. H. Borsodi, Borsodi Petroleum Company, pause for a chat in the lobby of the Adolphus Hotel

B. L. Majewski (left), of Deep Rock Oil Corporation, and Bill Boyd, executive vice-president, American Petroleum Institute, find time to have their picture taken

Roy B. Jones (left), Panhandle Refining Company, and Wirt Franklin, of Wirt Franklin Petroleum Corporation, listening intently to one of the speakers

The meeting afforded a number of the U. S. Bureau of Mines "boys" an opportunity to get together. H. B. Hill (left), Dallas, and H. C. Fowler, Washington, D. C.

Burdette Blue (left), president, I.T.I.O. Company; M. J. Kirwan (center), chief engineer, same company, and M. E. Montrose general sales manager, Lane-Wells Company, talk things over between sessions

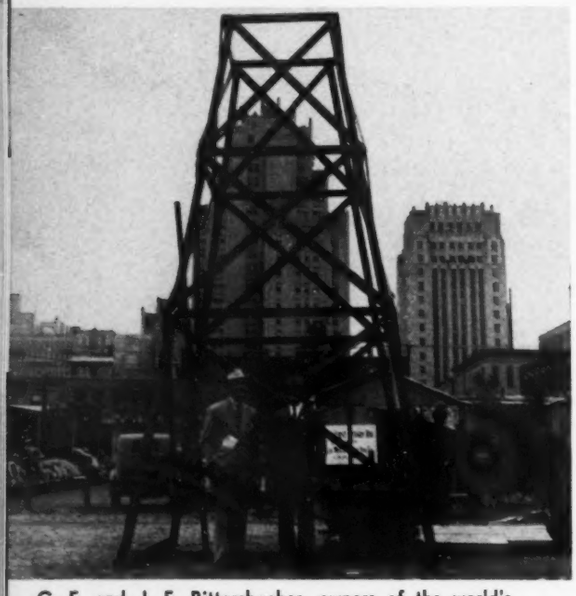
Harold B. Fell, chairman, Committee on Balance of Supply with Demand, presents his report. Frank Buttram, president of association, is an interested listener

At the Annual Banquet, one of the highlights of the I.P.A.A. meeting

Facing the camera are Marshall Young of Roeser & Pendleton (left), Harold B. Fell of the Association (center), and Edwin B. Cox of Cox & Hamon. Identity of the gentleman with his back to camera not known

J. L. Collins (left), vice-president of the Association for East Central Texas, presents bronze tablet to Joe E. Butler, president, Corsicana Chamber of Commerce, the city in which the first Texas oil was found.

World's first rotary rig and its co-owner, C. E. Rittersbacher. As a part of the celebration the rig was set-up and a wildcat test spudded-in in downtown Fort Worth. Power was supplied by the mule at left.



C. E. and J. E. Rittersbacher, owners of the world's first rotary. Their father, Charles Rittersbacher, drilled Texas' first oil well.

Texas Mid-Continent Oil and Gas Association Observes 45th Anniversary of Texas Oil Discovery— Fort Worth

Famous pioneer Texas oilmen: Left to right—Jack P. Shannon, C. D. Speed, Sr. (half hidden by Shannon), J. G. Hamill, A. W. Hamill, William M. Elliott, C. E. Rittersbacher, and Frank Pickrell.

A. W. Hamill, who drilled the Lucas discovery at Spindletop to open one of the most famous oil fields in the world, signs the scroll of honor.

A distinguished service award for outstanding contributions to the petroleum industry was presented to Jake L. Hamon (right). The presentation speech was by John G. Pew.

Jack P. Shannon breaks a bottle of oil from Texas' first well to christen the wildcat test that opened the observance of Texas oil's 45th birthday.

Granddaughter, daughter, and widow of oilmen, Mrs. Leone O'Donnell of Ranger, herself one of the few women oil operators in the world, took part in the ceremonies.

E. R. Brown (left), chairman of the board of Magnolia Petroleum Company, who built at Corsicana the first successful oil refinery in Texas, was presented with a distinguished service award. Julius Fohs made the presentation.

With A. I. M. E. in TULSA

The men to whom much of the credit must go for a most successful meeting. Left to right: W. H. Burke, Shell Oil Company, Inc., in charge of publicity; P. E. Fitzgerald, Dowell, Inc., in charge of the program arrangements; David G. Hawthorn, Amerada Petroleum Corporation, in charge of entertainment; and T. C. Frick, secretary-treasurer of Mid-Continent Section, A.I.M.E.

Prominent Louisiana delegates in attendance. Left to right: Sylvan Cromer and Benjamin C. Craft, Louisiana State University, and Glen R. Neighbors, associated with G. H. Neighbors, Shreveport, Louisiana

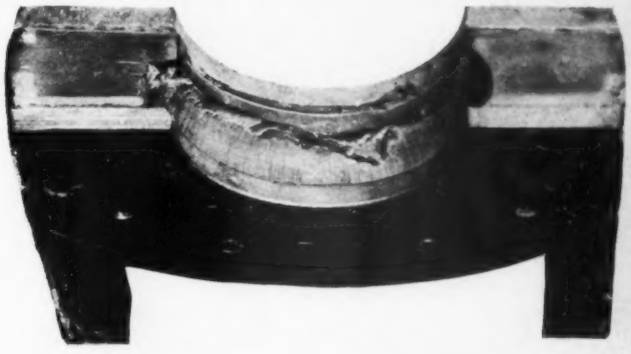
Dr. Morris Muskat, Gulf Research and Development Company, Pittsburgh

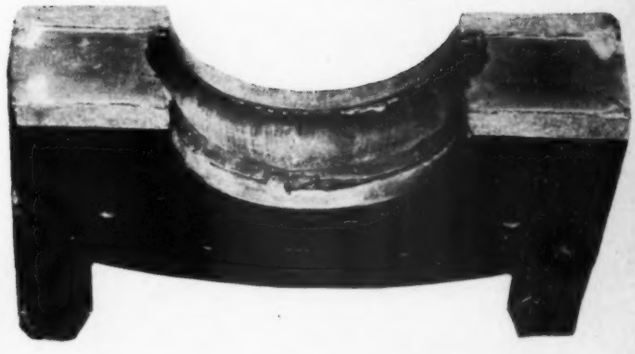
E. J. Kennedy, Jr., assistant to the secretary A.I.M.E., New York, and Prof. Benjamin C. Craft, Louisiana State University, with their heads together before the meeting started Thursday morning

M. C. Leverett, Humble Oil & Refining Company, Houston, Texas; D. L. Katz, University of Michigan, and H. L. Lightfoot, Humble Oil and Refining Company, Houston

Carl E. Reistle, Jr., M. H. Parks, and George B. Corless—all with the Humble Oil & Refining Company, Houston, Texas

BLOWOUTS THAT *Didn't* HAPPEN..





AND PIPE THAT *Didn't* STICK!

The two sets of Cameron Self-feeding Ram Packing Elements shown herewith are typical of many removed from the rams of Cameron Type SDA Blowout Preventers sent to our shops for cleaning and checking after long field service.

No definite service records on these packing elements are available, but their worn condition graphically tells the story of **blowouts that didn't happen, and of drilling strings that didn't stick.** They prove conclusively that Cameron Type SDA Preventers not only seal the annular space swiftly and positively when required to do so, but also permit safe movement of drill pipe or casing through the closed rams under pressure to prevent sticking. This is but one of the numerous features of superiority of Cameron Type SDA Preventers.

The complete dependability of Cameron Type SDA Blowout Preventers has won the unqualified endorsement of drillers, tool pushers, field superintendents and others responsible for the safe drilling and completion of high pressure oil wells. As a consequence, the Cameron Type SDA Blowout Preventer is virtually standard equipment on all high pressure drilling operations in the Gulf Coast, Mid-Continent and many foreign fields. Complete details will gladly be forwarded to any operator upon request.

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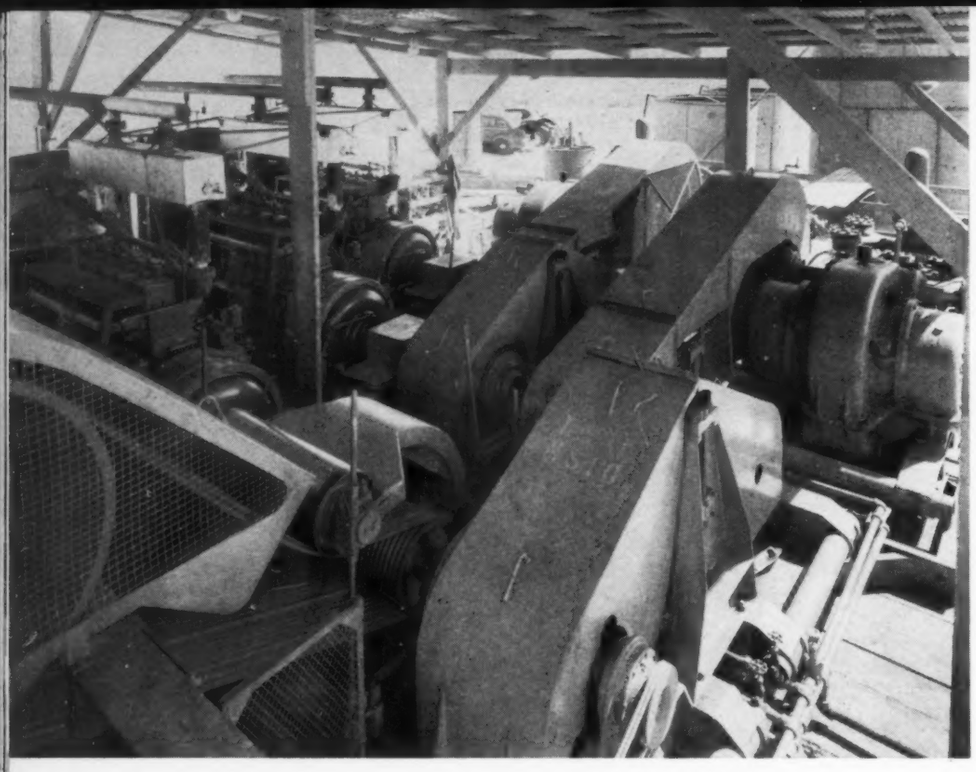


P 425.232

This rotary rig drive is now drilling at Coles Levee, California. The plan of the layout is shown in Fig. 2

EXCLUSIVE PETROLEUM ENGINEER FEATURE

By

WALLACE A. SAWDON

Pacific Coast and Foreign Editor

Use of Mechanical Rigs in Deep-Drilling Operations

Modern designs in engine drive and control provide flexible, fast operation

INTERNAL combustion engines using gas, gasoline, butane, or Diesel fuel have long been employed for various drilling operations but recent designs of rig equipment have made it possible to adapt them to the heaviest duty in rotary work. The advantages of power rigs under certain conditions involving mainly the availability and cost of water and/or fuel have been brought out in a previous article[1] in which a Wilson gas-engine-powered rig used to drill a well at Wheeler Ridge, California, to below 11,000 ft. was described. Within recent weeks, however, two new types of heavy-duty mechanical rotary drilling outfits have been put into service in California. Although the internal-combustion-engine-powered rig is becoming more widely used in the United States, foreign operating conditions have done much toward the development of design, and equipment somewhat comparable to the deep-drilling outfits now being employed in this country have been used in rotary-drilled fields of other countries for some time.

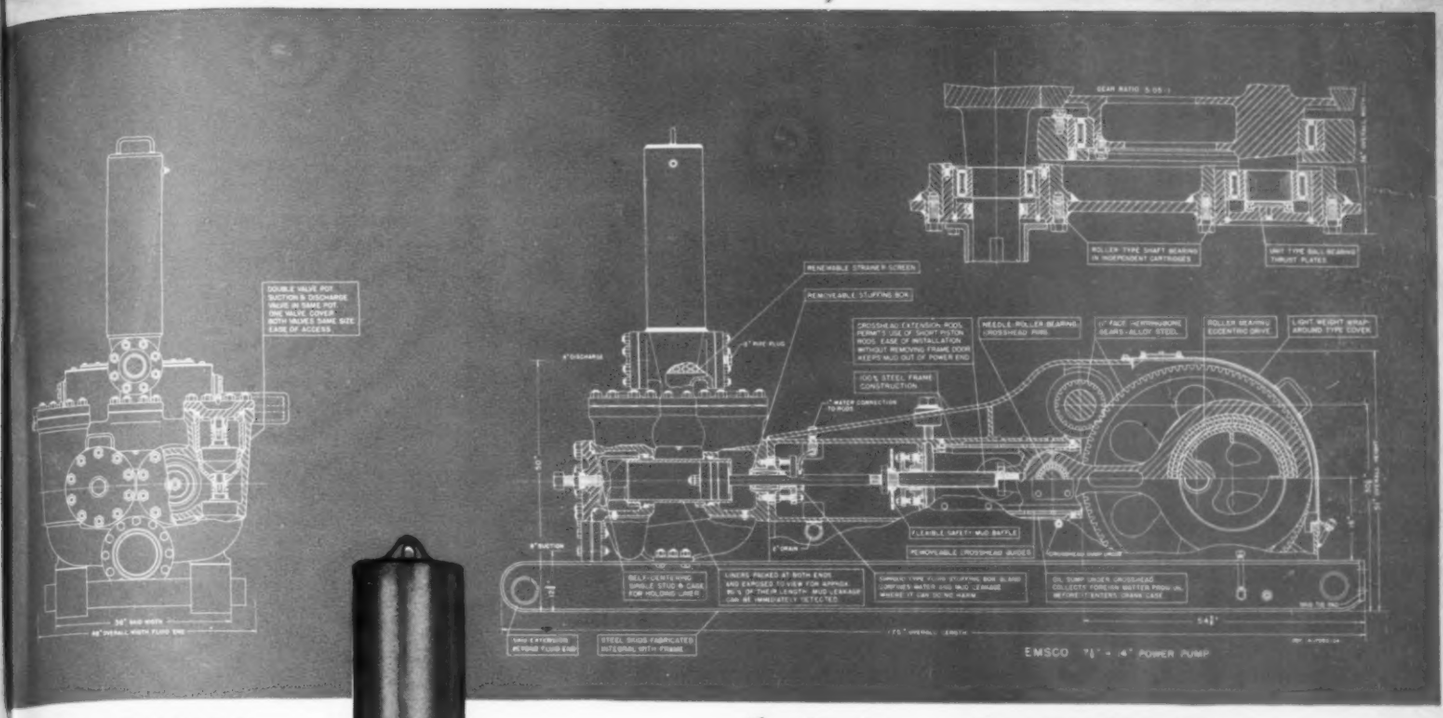
Foreign operators have long appreciated the benefits to be derived from the use of internal-combustion drilling equipment when specific circumstances have demanded conservation of fuel, water, and weight. A check-up shows that many years ago Diesel and gas engines of the larger types were used in Mexico by operators and contractors. These machines differed from the present trend in designs in that they used heavy-duty, slow-turning engines, cumbersome transmissions, and planetary reverse clutches. Generally, the drawworks was driven by one engine and the pump or pumps by another. There were, however, at that time operators who combined engines to drive either the drawworks or the pumps. One assembly of this type had two engines opposed, turning right-hand, with a gear interposed between them to compound. Through two friction clutches one engine acted as the reverse and the other forward.

In the light of present-day construction it is interesting to note that many of these rugged old machines are still in operation both in the United States and in foreign fields. Some of the single engine machines were moved from Mexico and are now operating as work-over rigs in Venezuela. They were generally of heavy construction and offered no premium for flexibility or ease of control; but they got the job done under rough and tumble conditions.

The dual compound, with engines side by side behind the drawworks compounded by V-belts and sometimes by open chains, came into its own through a period of development and has reached a high state of popularity. This design utilized the planetary reverse gear and friction clutch interposed between the engines and an eight-speed drawworks. Although the compound of V-belts remained popular, the enclosed flood-lubricated, multiple-strand chain transmission showed an advantage from the standpoint of compactness and many manufacturers adopted it.

With this system flexibility of compounding engines and additions of auxiliaries within a compact unit has become practically unlimited. Two, three, and four engines are often compounded to drive one, two, or three pumps that may either be hydraulically or mechanically compounded. Balanced with available horsepower we find washdown pumps, air compressors, and even generators being driven from the

[1] "Internal Combustion Engines Used in California Deep Drilling," by Wallace A. Sawdon, *The Petroleum Engineer*, Feb., 1940.



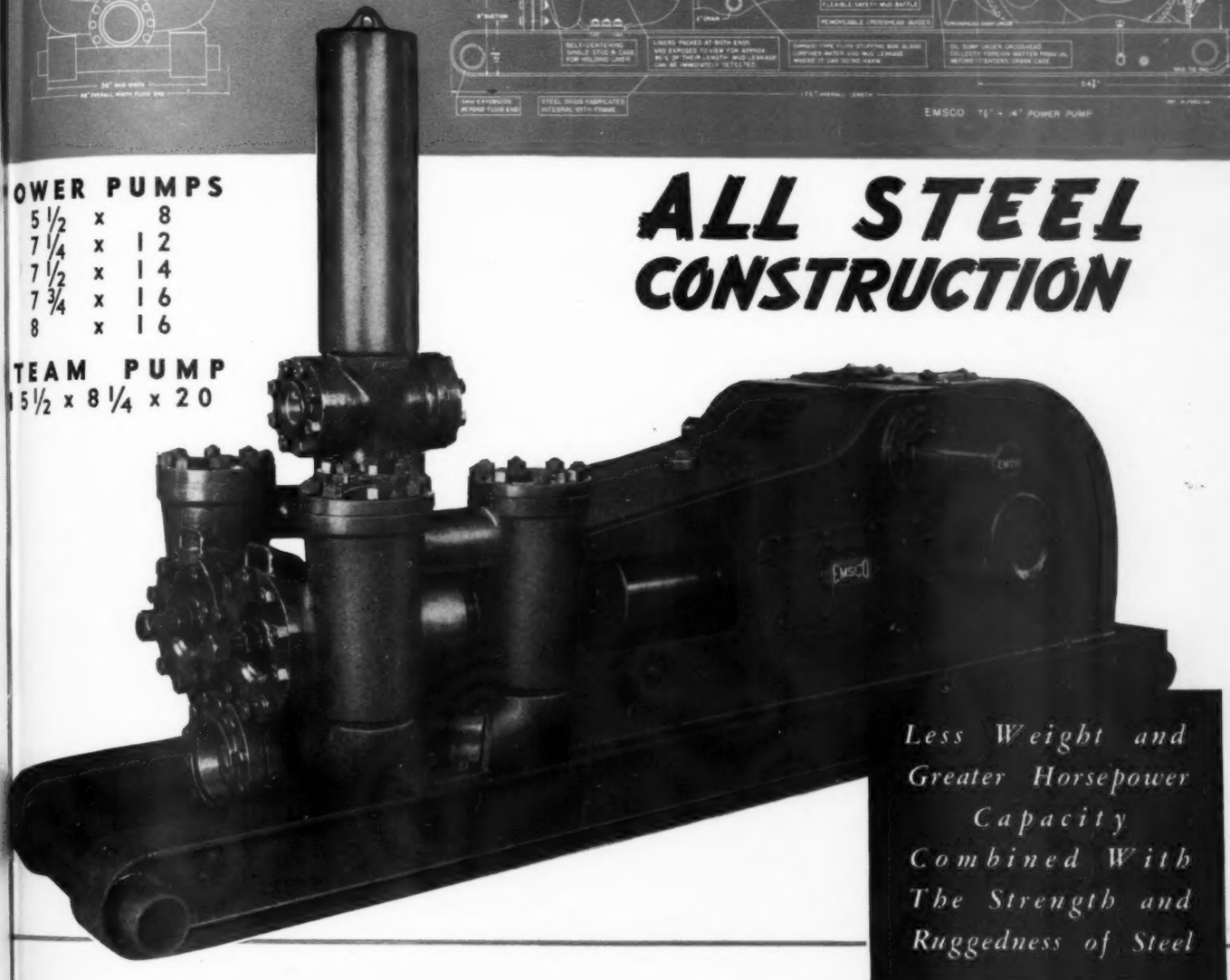
POWER PUMPS

5 1/2 x 8
7 1/4 x 12
7 1/2 x 14
7 3/4 x 16
8 x 16

STEAM PUMP

15 1/2 x 8 1/4 x 20

ALL STEEL CONSTRUCTION



Less Weight and Greater Horsepower Capacity Combined With The Strength and Ruggedness of Steel

To build pumps with greater horsepower capacity and less weight for a given size than ever had been accomplished previously . . . that was the objective of Emsco engineers when designing these pumps. It was not a simple problem, but one of tremendous importance to the oil industry. How well they succeeded is clearly evidenced by the current types of Emsco advanced slush pumps.

Emsco pumps are all-steel; with fabricated power ends and steel fluid ends. Enormous reductions in weight over conventional construction is affected. Also, greater strength than ever has been available in this type of equipment.

Users express their approval of Emsco pumps by repeat orders. There are reasons . . . reasons that are vitally important to operators. Less weight combined with the strength and ruggedness of steel is only one. Others are illustrated above.

EMSCO DERRICK AND EQUIPMENT COMPANY

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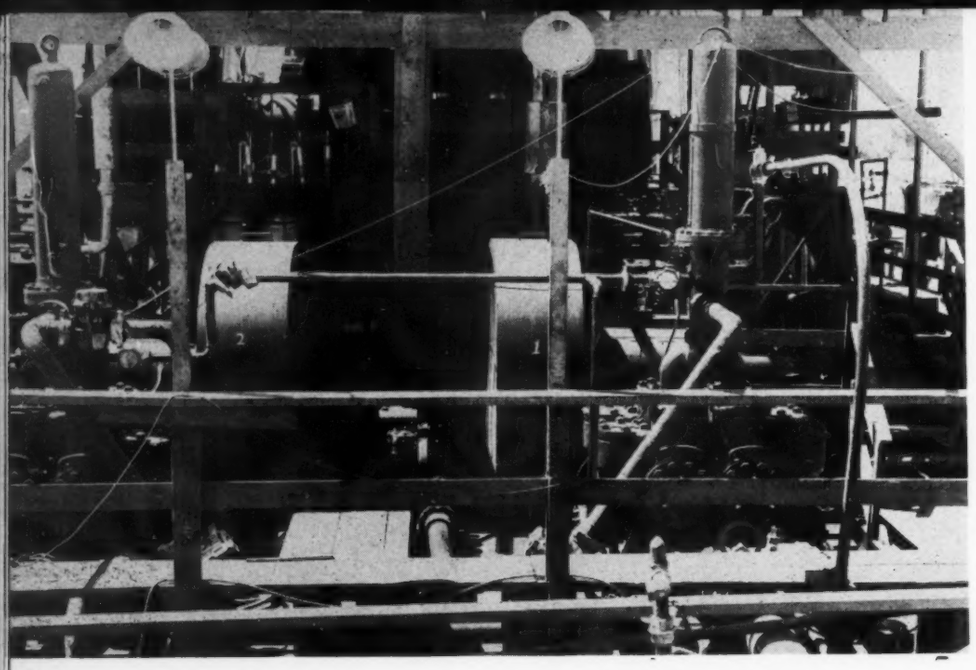
EMSCO SLUSH PUMPS



This transmission, used at Coles Levee, includes three 350-hp. gas engines, all directly compoundable through chain transmission to drawworks or pumps

main engines. These engines are available individually or in groups to the drawworks or to the pumps, depending upon the most urgent power need.

An illustration of the application of large mechanical rigs for foreign drilling is an Emsco machine driven by four D-17000 Caterpillar Diesel engines now in use in Venezuela. This machine has the four engines available in all combinations to any of three mud pumps or the drawworks through a flood-lubricated chain transmission. The machine is of extremely simple construction, having only the one master friction clutch in conjunction with a planetary reverse gear. The other clutches, exclusive of the friction engine service clutches, are of the multiple-jaw type. These clutches are not only in the transmission but also in the drawworks. This method of construction lacks operating flexibility but makes up for this drawback in ease of field repair and in continued operation over long periods of time.

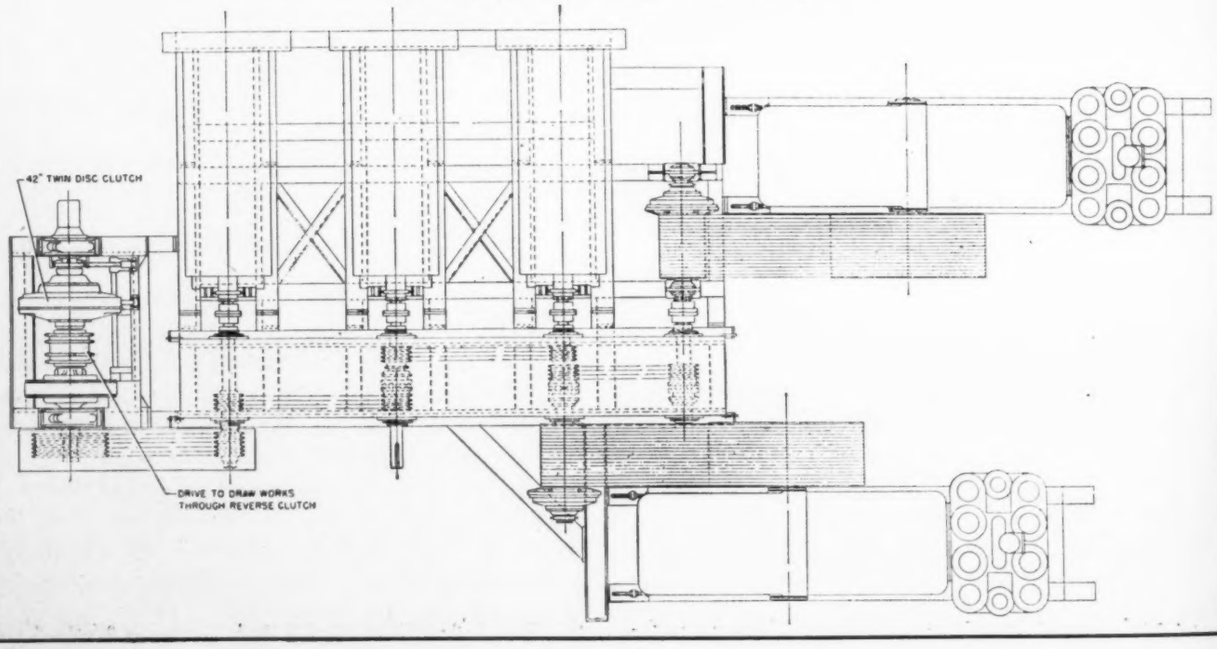
Domestic operations, however, give the manufacturer greater opportunity for proof of designs; and installations recently made at Coles Levee, California, are demonstrating the adaptability of mechanical rotary rigs in the development of deep fields. Here are found in use the largest internal-combustion-engine rigs, as to horsepower, ever built.

One of these rigs is equipped with three LeRoi gas engines compounded continuously (by operator's preference) through a chain transmission. These engines have a manufacturer's rating of 350 hp. at 900 r.p.m. As originally supplied, this machine had two engines and one pump. A third engine and another pump were installed after the first hole drilled showed a lack of pump capacity. At present this rig has drilled three 9200-ft. holes in rapid time, one of which was the fastest recorded in that area to date for power or steam rigs. The first well was drilled with butane as fuel but on the others natural gas was used as fuel.

A typical layout for this rig is shown in Fig. 1 and details of the arrangement of the equipment are illustrated in accompanying photographs. The speed of the rig is comparable to steam. Actual timing going in the hole shows 60 stands of 5-9/16-in. drill pipe handled in 55 minutes and 90 stands in one hour and 25 minutes. The operator informs that he comes out of the hole in two hours and a few minutes average with 90 stands of the above pipe.

The main equipment on this rig consists of an Emsco ECA drawworks, with a JA reverse clutch, JM-3 transmission, and two Gardner-Denver 20-in. pumps, the drawworks, rotary table

Fig. 1. Layout for Emsco mechanical rig



KEROTEST

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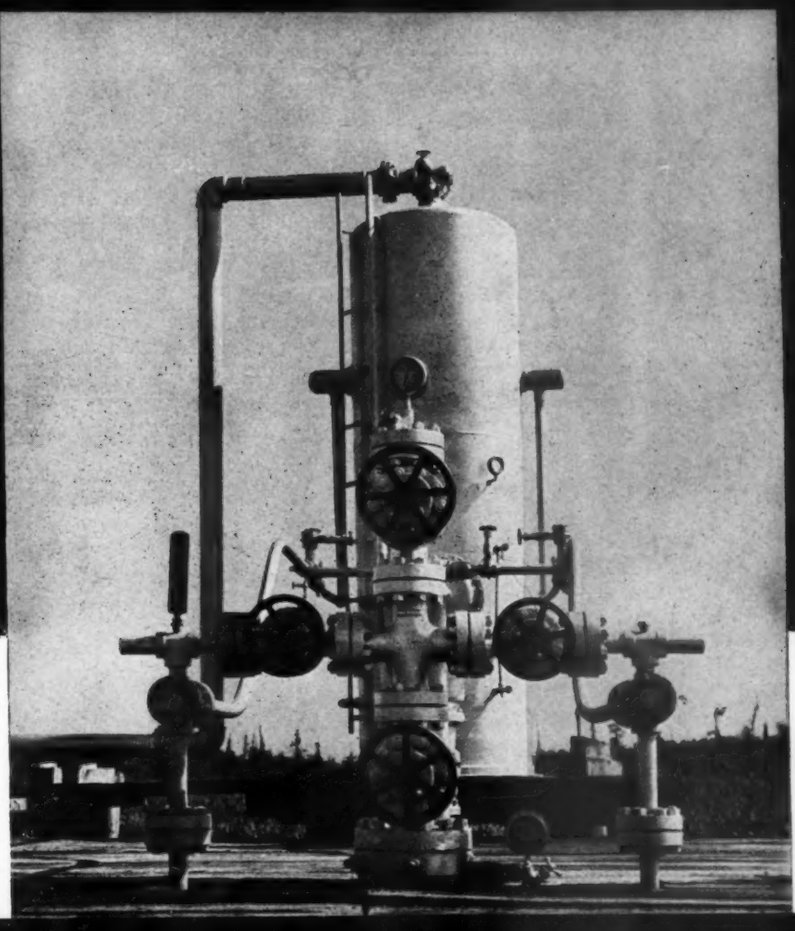
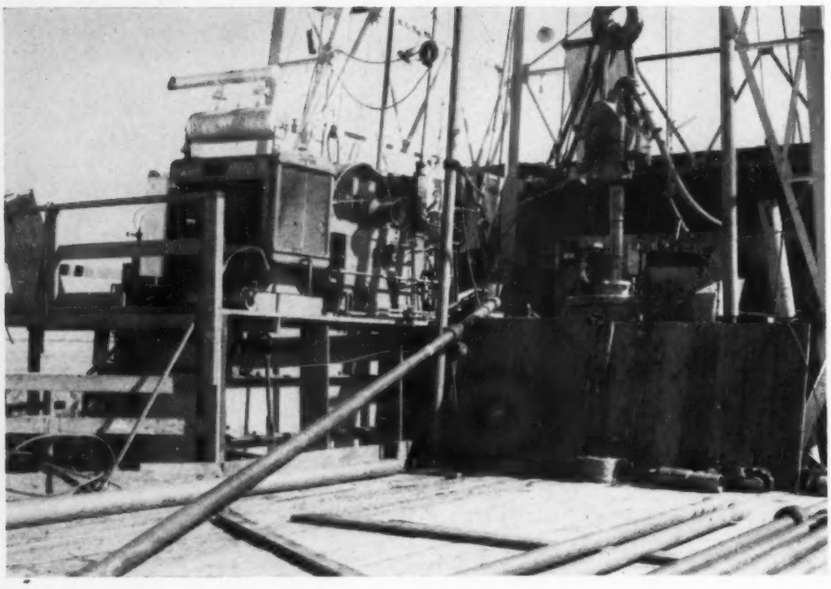


KEROTEST



The standby unit used on this well, which is being drilled with the rig illustrated in Fig. 2, is a Wilson Giant Model double drum drawworks mounted as a unit with a 160-hp. Waukesha gas engine

and pumps being driven by the three 350-hp. gas engines. All three engines are tied into the transmission at all times, even when compounding the pumps. V-belts and friction clutches are used on the pump drives.

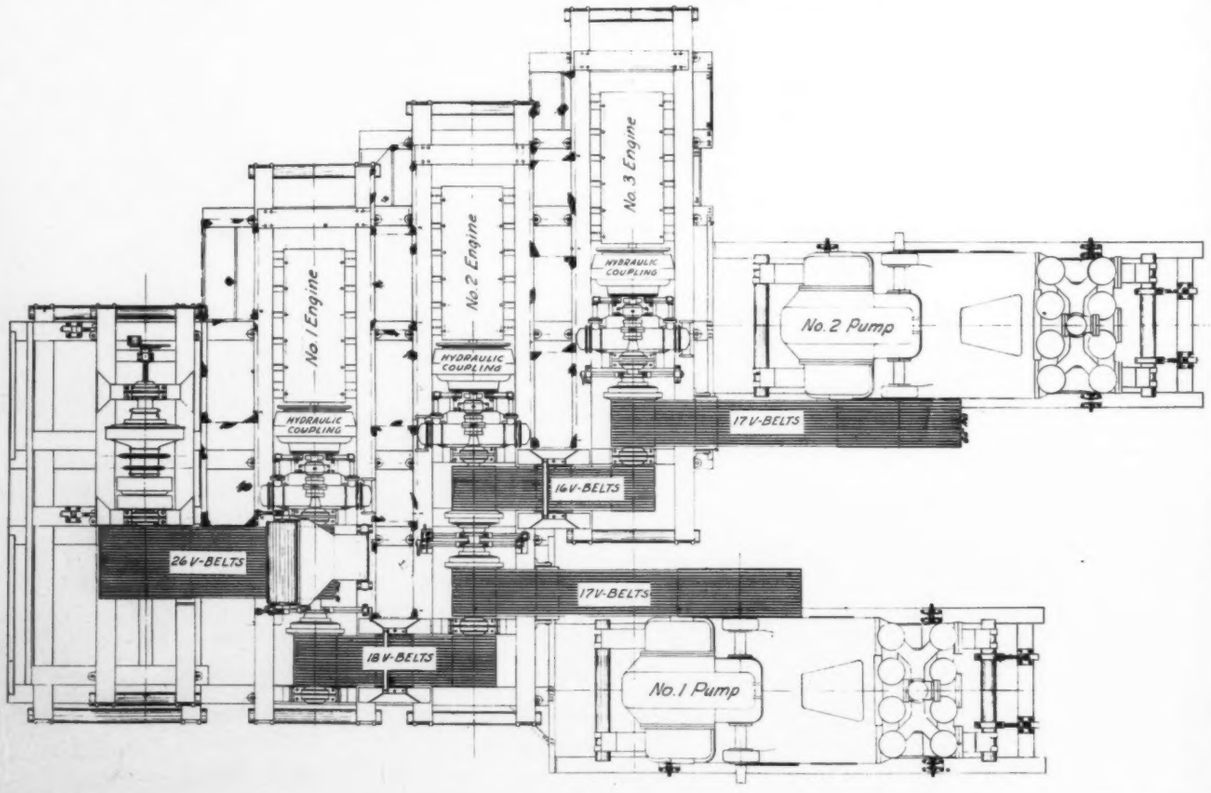
The JA clutch employs a 36-in. Twin Disc clutch. Normally the manufacturer would supply a 42-in. or Type "K" clutch with a rating of 1200 hp. at 350 r.p.m. for anything over 900 hp. but, as the extra engine was added after the first hole was drilled, the clutch was not changed. The clutch used is the largest now on the market for service with an instantaneously reversible planetary gear.

There are many drilling machines on the market of types different from the ones discussed above. These types employ, for the most part, a multiplicity of friction clutches operated by means of manual, air or hydraulic controls. The machines are most popular in the sizes of less than 600 hp. They are noted for their extreme flexibility in operation with finger-light controls and general high-speed performance. The machines have friction clutches in the drums on the high- and in some cases on the low-speed sides as well as friction clutches in the speed-changing transmissions and often in the compounding transmissions.

Definitely on the side of increased performance, we are witnessing the advent of the hydraulic drive in several forms. Hydraulic couplings have for several years received the attention of manufacturers but their adoption until recently has been entirely in foreign fields. At present they are used on rigs in New Zealand, the Netherlands, East Indies, Egypt, and Trinidad.

As applied in foreign fields the cou-

Fig. 2. Layout for National mechanical rig using hydraulic couplings and V-belt drives to drawworks and pumps



A typical contractor's power rig with two 335-hp. Waukesha gas engines compounded through an Emsco three-shaft chain transmission. An Emsco 7¾ by 16 welded steel pump is driven from the third shaft. Reverse clutch is a Type "VA" with 36-in. Twin Disc clutch

plings are generally swung between pedestal bearings, between the prime mover and the transmission. Until recently there have been no drilling rigs with hydraulic couplings in use in this country but within the last few weeks a 3-engine rig of this type has been placed in service. The arrangement of this rig is shown in Fig. 2 and views of it are given in the accompanying photographs.

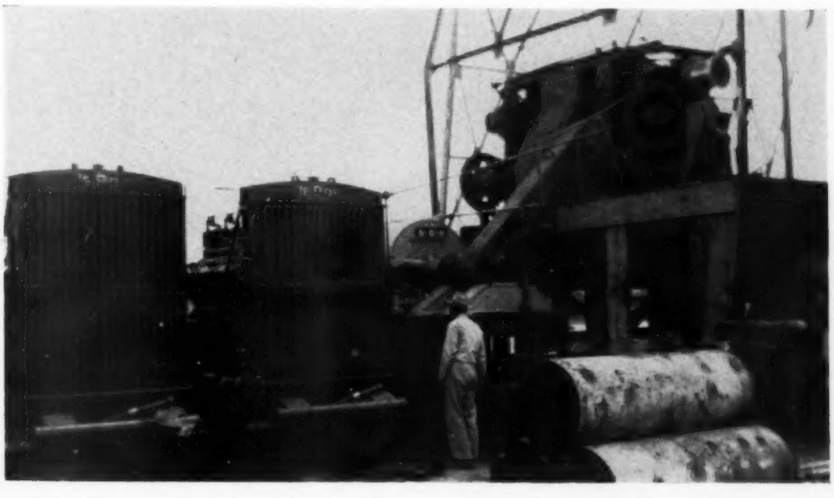
Power is supplied by three Waukesha gas engines that at the present time are using natural gas as fuel. These engines have a manufacturer's rating of 335 hp. at 900 r.p.m. The other equipment includes an Ideal 23-10½ F. E. drawworks and two Ideal C-350, 18-in. pumps. V-belt drives are employed for pumps and drawworks. The hydraulic couplings are the scoop-controlled type bolted to the flywheel of the engine and supported on the outside by an outboard bearing. Regulation of the scoop control on each coupling to meet drilling conditions is done by remote hydraulic control from the driller's position. Power for hoisting and rotating as well as for pump operation is through hydraulic couplings on this rig.

A reverse gear is used to take the power from the engines and deliver it to the drawworks and provides a means of reversing the drawworks drive. The reverse gear has forward, neutral, and reverse positions and is equipped with hydraulic controls. A standby unit is placed opposite the main drawworks and consists of a Wilson Giant Model double drum drawworks mounted as a unit with a 160-hp. Waukesha gas engine.

As previously noted, hydraulic couplings have been used in foreign fields for some time but greater opportunities to study the performance of internal-combustion engine rigs equipped with hydraulic couplings are now offered by this installation. After the first well has been completed there will be more valuable performance data available. This type coupling has been found most advantageous for pump operation as the operator can run his pump from maximum speed to a complete stall and maintain the stalling pressure on the fluid so long as desired. Questionable is the saving in engine wear, which in the light of present engine performance shows remarkable periods of service when the engines are properly cared for. The industry is closely watching this application of the hydraulic coupling.

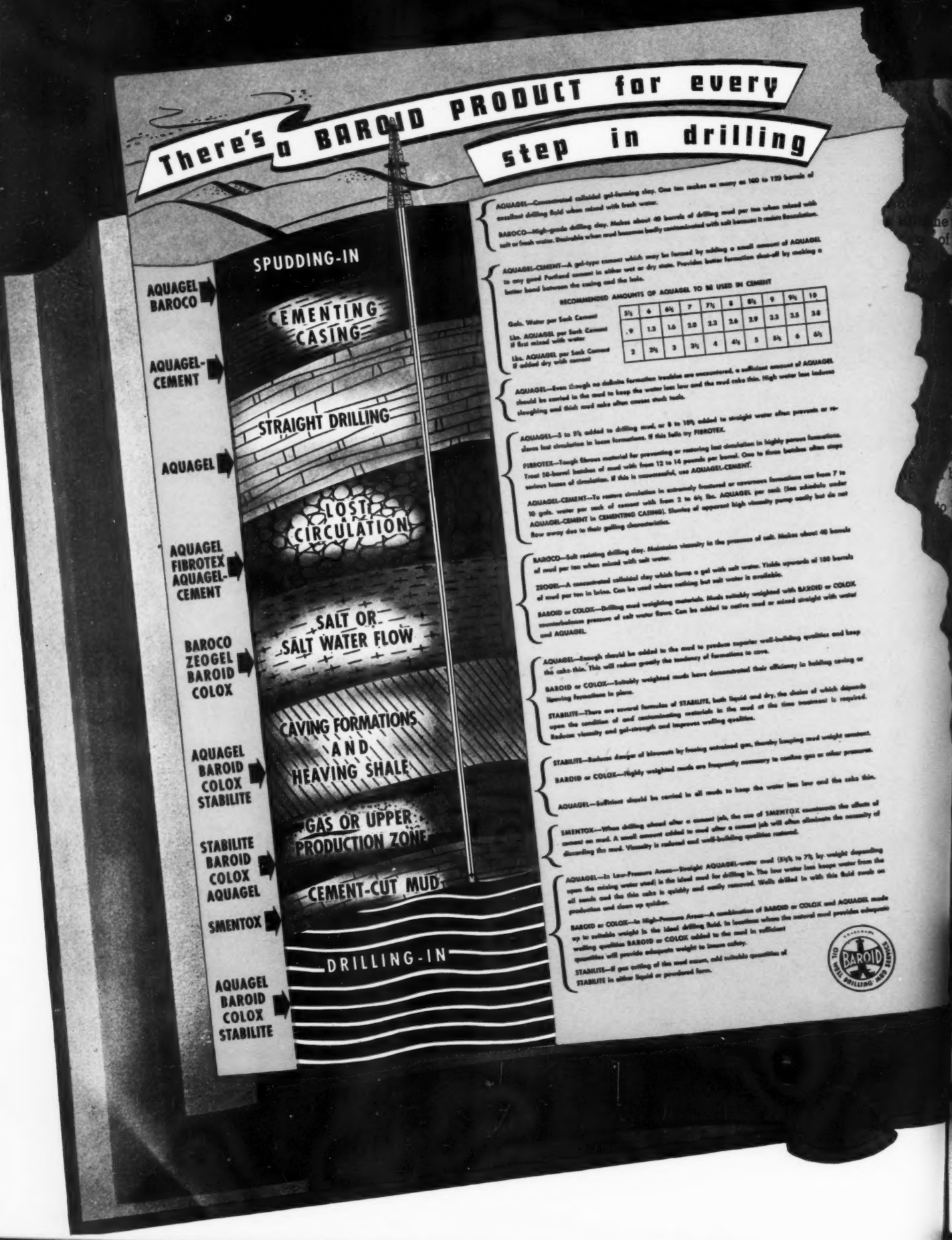
The hydraulic coupling has eliminated shock conveyance through chains and thus provides for more effective use of chain-compounding transmission. Although the chain-compounding transmission has not yet been used with hydraulic couplings in this country it appears to offer advantages, particularly in foreign fields.

Of the hydraulic transmissions we find the torque converter becoming increasingly popular. For several years, machines have been on the market so equipped but the popular types at present are in the range of 150 hp. and the converters having fixed blades are limited in torque output to the speed of the engine. In the experimental stage is a 600-hp. torque converter manufactured by Worthington and being used by a contractor on an Emsco rig. This torque converter not only gives a high efficiency characteristic and an infinite speed range in forward but also has a neutral and reverse. It is still too early to pass mature judgment on the application but from observation it would appear that this type of hydraulic drive may be somewhat revolutionary in altering present concepts of internal-combustion drilling machine practices.



An experimental drive powered by two 350-hp. LeRoi gas engines and using a Worthington torque converter that can be seen between the engines and the drawworks. The engines are compounded through an Emsco chain transmission

Here's THE MOST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GAS OR UPPER PRODUCTION ZONE
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DRILLING-IN
AQUAGEL BAROCO
AQUAGEL-CEMENT
AQUAGEL
AQUAGEL FIBROTEX AQUAGEL-CEMENT
BAROCO ZEOGEL BAROID COLOX
AQUAGEL BAROID COLOX STABILITE
STABILITE BAROID COLOX AQUAGEL
SMENTOX
AQUAGEL BAROID COLOX STABILITE
AQUAGEL—Concentrated colloidal gel-forming clay. One ton makes as many as 160 to 170 barrels of excellent drilling fluid when mixed with fresh water.
BAROCO—High-grade drilling clay. Makes about 40 barrels of drilling mud per ton when mixed with salt or fresh water. Desirable when mud becomes badly contaminated with salt because it resists flocculation.
AQUAGEL-CEMENT—A gel-type cement which may be formed by adding a small amount of AQUAGEL to any good Portland cement in either wet or dry state. Provides better formation shut-off by making a better bond between the casing and the hole.
RECOMMENDED AMOUNTS OF AQUAGEL TO BE USED IN CEMENT
Gals. Water per Sack Cement
Lbs. AQUAGEL per Sack Cement if first mixed with water
Lbs. AQUAGEL per Sack Cement if added dry with cement
5½ 6 6½ 7 7½ 8 8½ 9 9½ 10
.9 1.3 1.6 2.0 2.3 2.6 2.9 3.3 3.5 3.8
2 2½ 3 3½ 4 4½ 5 5½ 6 6½
AQUAGEL—Even though no definite formation troubles are encountered, a sufficient amount of AQUAGEL should be carried in the mud to keep the water loss low and the mud cake thin. High water loss induces sloughing and thick mud cake often causes stuck tools.
AQUAGEL—3 to 5% added to drilling mud, or 8 to 10% added to straight water often prevents or reduces lost circulation in loose formations. If this fails try FIBROTEX.
FIBROTEX—Tough fibrous material for preventing or restoring lost circulation in highly porous formations. Treat 50-barrel batches of mud with from 12 to 14 pounds per barrel. One to three batches often stops various losses of circulation. If this is unsuccessful, use AQUAGEL-CEMENT.
AQUAGEL-CEMENT—To restore circulation in extremely fractured or cavernous formations use from 7 to 10 gals. water per sack of cement with from 2 to 6½ lbs. AQUAGEL per sack (See schedule under AQUAGEL-CEMENT in CEMENTING CASING). Slurries of apparent high viscosity pump easily but do not flow away due to their gelling characteristics.
BAROCO—Salt resisting drilling clay. Maintains viscosity in the presence of salt. Makes about 40 barrels of mud per ton when mixed with salt water.
ZEOGEL—A concentrated colloidal clay which forms a gel with salt water. Yields upwards of 100 barrels of mud per ton in brine. Can be used where nothing but salt water is available.
BAROID or COLOX—Drilling mud weighting materials. Muds suitably weighted with BAROID or COLOX counterbalance pressure of salt water flows. Can be added to native mud or mixed straight with water and AQUAGEL.
AQUAGEL—Enough should be added to the mud to produce superior well-building qualities and keep the cake thin. This will reduce greatly the tendency of formations to cave.
BAROID or COLOX—Suitably weighted muds have demonstrated their efficiency in holding caving or heaving formations in place.
STABILITE—There are several formulas of STABILITE, both liquid and dry, the choice of which depends upon the condition of mud contaminating materials in the mud at the time treatment is required. Reduces viscosity and gel-strength and improves wetting qualities.
STABILITE—Reduces danger of blowouts by freeing entrained gas, thereby keeping mud weight constant.
BAROID or COLOX—Highly weighted muds are frequently necessary to confine gas or other pressures.
AQUAGEL—Sufficient should be carried in all muds to keep the water loss low and the cake thin.
SMENTOX—When drilling ahead after a cement job, the use of SMENTOX counteracts the effects of cement on mud. A small amount added to mud after a cement job will often eliminate the necessity of dressing the mud. Viscosity is reduced and well-building qualities restored.
AQUAGEL—In Low-Pressure Areas—Straight AQUAGEL-water mud (3½% to 7% by weight depending upon the mixing water used) is the ideal mud for drilling in. The low water loss keeps water from the oil sands and the thin cake is quickly and easily removed. Wells drilled in with this fluid result in production and clean up quicker.
BAROID or COLOX—In High-Pressure Areas—A combination of BAROID or COLOX and AQUAGEL muds up to suitable weight is the ideal drilling fluid. In locations where the natural mud provides adequate weight qualities BAROID or COLOX added to the mud in sufficient quantities will provide adequate weight to insure safety.
STABILITE—If gas cutting of the mud occurs, add suitable quantities of STABILITE in either liquid or powdered form.
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IMPORTANT PAGE *from the* BOOK OF DRILLING EXPERIENCE

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Vapor-Liquid Phase Equilibria in Hydrocarbon Systems

Calculating the heat balance in a fractionating tower

Part XI

By GEORGE GRANGER BROWN
Professor of Chemical Engineering, University of Michigan
and
DYSART E. HOLCOMB

Photographs and biographical sketches of the writers can be found on page 31 of the July issue of *The Petroleum Engineer*, in connection with Part VII.

AFTER having determined the number of plates and the reflux ratio (L/V) within the column, the quantity of heat to be supplied at the bottom, and the heat removed from, or the quantity of external reflux to be pumped back to, the top are determined by a heat balance around the fractionating tower.

The most convenient way of making a heat balance is to have charts or tables giving the enthalpy (or "heat content") of each component in the liquid and vapor state at the required temperature and pressure. The thermal data given in Figs. 23, 24a, and 24b are plotted as functions of temperature. These charts are based on a critical review of all available experimental data and have been found to be accurate and consistent with the equilibrium data, heat capacities, latent heats, and Joule-Thomson coefficients.

The data of Fig. 23 are based on atmospheric pressures, but may also be used for the enthalpy of the liquid hydrocarbons above 32°F. for pressures of as high as 300 lb. per sq. in. without introducing an error greater than 200 B.t.u. per lb. mole.

The enthalpies of the vapor hydrocarbons plotted as functions of temperature for a pressure of 200 lb. per sq. in. gauge in Figs. 24a and 24b are also referred to the liquid hydrocarbons at 32°F. under one atmosphere pressure so that the values read from Figs. 23, 24a, and 24b may be added and subtracted directly in making heat balances.

The values plotted in Figs. 24a and 24b have been obtained from data of Fig. 23 by adding the difference in enthalpy between the component existing as a liquid in equilibrium with vapor and as a vapor at the same indicated temperature and under a pressure of 200 lb. per sq. in. gauge. This difference in enthalpy may be obtained by use of the well-known equation applicable to two-phase equilibria:

$$\frac{d \ln K}{dT} = 2.303 \frac{d \log_{10} K}{dT} = \frac{\Delta H}{RT^2} \quad \ldots\ldots\ldots\ldots \quad (47)$$

In this equation K is the equilibrium constant as given in Fig. 13. The value for $(d \log K/dT)$ is the slope of the curve of log K plotted against temperature as given in these same figures. The ΔH is the enthalpy of the hydrocarbon in the vapor state minus the enthalpy of the hydrocarbon in the equilibrium liquid. R is the universal gas constant, and T the absolute temperature.

The slope of log K vs. temperature may be approximated by placing a ruler tangent to the curve for the equilibrium constant as given in Fig. 13 at the desired temperature and pressure and reading the increase in temperature between the values at which $K = 1$ and $K = 10$. The slope of log K vs. T or $(d \log K/dT)$ is equal to $1/\Delta T$ so determined. As the slope must be expressed on the basis of natural logarithms, and the value for R is 1.986, the equation may be rearranged and written as follows:

$$\Delta H = \frac{d \log_{10} K}{dT} 4.59\, T^2$$

Inasmuch as the slope expressed as $d \log_{10} K/dT$ is equal to $1/\Delta T$ obtained by placing the ruler in the manner indicated, then:

$$\Delta H = \frac{4.59\, T^2}{t_{(K=10)} - t_{(K=1)}}$$

B.t.u. per lb. mole . . . . (48)

In this way the increase in enthalpy between the component as a liquid and the component as a vapor in B.t.u. per lb. mole may be obtained for any temperature and pressure from the plot of the equilibrium constant, Fig. 13.

The values given in Figs. 24a and 24b were obtained by careful differentiation of the log K vs. T curve and were checked by computations involving the normal latent heat of vaporization and the effect of pressure on the enthalpy of hydrocarbon vapors with consistent results. For this reason Figs. 23, 24a, and 24b represent thermal data that are consistent with the equilibrium data given in Fig. 13.

The data of Figs. 23, 24a, and 24b are used to compute a heat balance for the separation of Table 9 conducted in a column of 21 equilibrium plates, or 23 equilibrium steps including partial condenser and reboiler. As indicated in Table 23 such separation may be accomplished with 23 equilibrium steps with an internal reflux ratio (L/V) of about 0.785.

If the column is operating with a partial condenser, and the condensate separated in the separator is returned in its entirety to the column at its bubble point, the quantity of liquid so returned as external reflux is approximately the same as the quantity of liquid flowing downward from plate to plate within the column. Under these conditions the ratio of external reflux to overhead distillate (R/D) may be determined directly from the material balance equation:

$$L = V - D$$

By dividing by L:

$$\frac{V}{L} - \frac{D}{L} = 1 \quad \ldots\ldots \quad (49)$$

$$\frac{L}{D} + 1 = \frac{\frac{L}{V}}{\frac{L}{V} - 1} \quad \ldots \quad (49a)$$

From this equation L/D is found to be 3.635 for the value $L/V = 0.785$, indicating that the moles of liquid external reflux at its bubble point is 3.635 times the moles of distillate.

Although this simple procedure for computing the external reflux is usually satisfactory when all of the distillate is removed as a gas and the external reflux is returned as a liquid at its bubble point, it is frequently necessary to make allowance for the temperature of the reflux being below its bubble point as when a total condenser is used. This may be approximated readily by means of the data in Fig. 23, and Figs. 24a and 24b for 200 lb. per sq. in. gauge pressure, by computing the increase in

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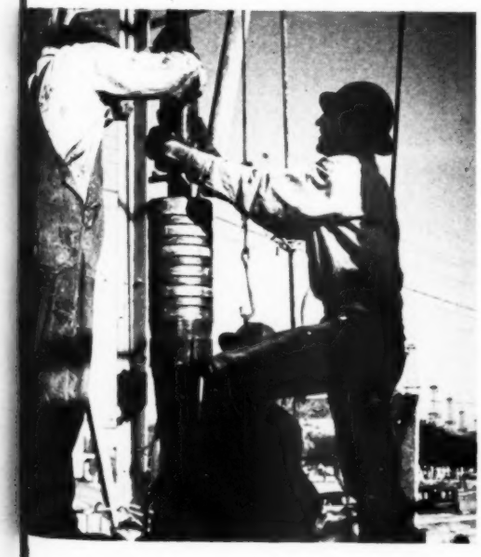

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TABLE 23a

Component	From Fig. 23 h in liquid at 110°F.	From Fig. 23 h in liquid at 60°F.	Col. 2 minus Col. 3	From Fig. 24 H in vapor at 215 lb. per sq. in. 110°F.	Col. 5 minus Col. 2	Mole fraction in external reflux	Col. 4 times Col. 7 Δ/h (60°-110°F.)	Col. 6 times Col. 7 (H-h) 110°F.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C_3H_8	1750	550	1200	5850	4100	0.0708	85	290
C_4H_{10}	2050	650	1400	7800	5750	0.6647	931	3822
i-C_5H_{12}	2400	800	1600	9300	6900	0.2342	375	1616
n-C_5H_{12}	2600	850	1750	9800	7200	0.0303	53	218
							1444	5946

enthalpy of the liquid reflux between its actual temperature and its bubble point, and the difference in enthalpy between liquid and vapor at the bubble point as follows:

For the case under consideration, the composition and quantity of the overhead distillate are given in Table 9, and the composition of the liquid reflux is given in the last column of Table 10. The calculations are given in Table 23a.

If the external reflux is supplied at its bubble point, about 110°F. (109°F. as computed), 3.635 moles of reflux must be supplied per mole of distillate. As the distillate is 0.408 moles per mole of feed, $3.635 \times 0.408 = 1.483$ moles of external reflux at 110°F. must be supplied per mole of feed. If the reflux is supplied at 60°F. instead of 110°F. the quantity of reflux required will be such that the same quantity of heat is absorbed by the cold reflux on the top plate of the column. If we assume the latent heat of vaporization is the same for the reflux on the top plate as at 110°F.

$$R_{60}(h_{110}-h_{60}+H_{110}-h_{110}) = R_{110}(H_{110}-h_{110})$$

$$R_{60}(1444+5946) = 1.483\,(5946)$$

$$R_{60°} = \frac{8818}{7390} = 1.19$$

An accurate heat balance may be made around the top of the fractionating column for the purpose of determining the internal reflux ratio (L/V) for any specified external reflux regardless of the temperature of the external reflux. The following procedure will make clear the method. Using the same column separation as given in Table 9, and the following operating conditions:

External reflux ratio, R/D, = 3.6

Distillate, D, = 0.408 moles per mole of feed

External reflux, R, = 1.47 moles per mole of feed

Vapors rising from the top plate in the column (second equilibrium step), $V_2 = R + D = 1.878$ moles per mole of feed.

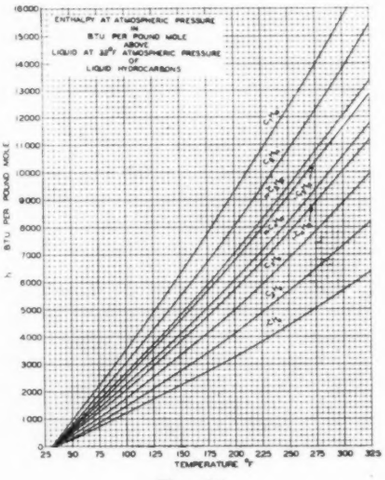
ENTHALPY AT ATMOSPHERIC PRESSURE IN B.T.U. PER POUND MOLE ABOVE LIQUID AT 32° F. ATMOSPHERIC PRESSURE OF LIQUID HYDROCARBONS
B.T.U. PER POUND MOLE
TEMPERATURE °F
C3H8
C4H10
i-C5H12
n-C5H12

Fig. 23

The quantity of liquid flowing down from the second equilibrium step, L_2 (this is the top plate in the column when the partial condenser is used) is greater than the quantity of cold reflux introduced on the second step because the introduction of the cold reflux causes some of the vapors, V_3, to condense in heating the cold reflux to the temperature of V_2. The quantity L_2 and quantity V_3 can be determined by a heat and material balance around the top of the column as follows:

$$L_2 = V_3 - D$$

$$V_3H_3 = L_2h_2 - Rh_R + V_2H_2$$

Substituting $V_3 - D$ for L_2 and simplifying:

$$V_3(H_3-h_2) = V_2H_2 - Dh_2 - Rh_R$$

$$V_3 = \frac{V_2H_2 - Dh_2 - Rh_R}{H_3-h_2} \quad . \quad (50)$$

The values for H_2, h_2 and h_R may be determined from the molal enthalpies given in Figs. 23 and 24 by multiplying them by the mole fraction of each component in the corresponding streams V_2, L_2, as computed above, and the mole fraction in the reflux as shown in Table 25.

The values in the third column of Table 25 are computed by multiplying the enthalpy listed in the second column by the mole fraction determined in the fifth column of Table 24. Similarly the values in the fifth column are computed by multiplying the enthalpies in the fourth column by the mole fraction given in column 7 of Table 24. The last column of Table 25 is obtained by multiplying the enthalpy of column 6 by the mole fraction in the reflux as given in the last column of Table 10 which has also been repeated above in the first computation tabulated.

The only values unknown in equation (50) are now V_3 and H_3. As the pressure is fixed, the temperature of the vapors V_3 is determined solely by their composition. If the temperature and composition are known, these factors determine the value for H_3. There is another relationship between V_3 and H_3, therefore, but unfortunately it cannot be substituted in equation (50) so as to obtain a straightforward solution. It is therefore necessary to estimate or assume a value for H_3, compute the corresponding value of V_3 and then check to see if the assumed value

TABLE 25
Computation of enthalpy

Component	V_2 130°F. B.t.u. per mole (Fig. 24)	V_2 130°F. H_2	L_2 130°F. B.t.u. per mole (Fig. 23)	L_2 130°F. h_2	R 101°F. B.t.u. per mole (Fig. 23)	R 101°F. h_R
(1)	(2)	(3)	(4)	(5)	(6)	(7)
C_2	6280	646	2220	65	1480	105
C_3	8340	5540	2700	1463	1800	1198
i-C_4	9900	2045	3150	1158	2150	500
C_4	10480	270	3310	201	2260	69
		H_2=8501		h_2=2887		h_R=1872

TABLE 24
Computation of the composition of the vapor and liquid on the second equilibrium step

Component	Moles of distillate per mole of feed D	Moles of external reflux per mole of feed R	V_2 R+D	Comp. of V_2	Equilibrium constant K at 215 lb. per sq. in. and 130°F.	Mole fraction L_2 Col. 5 divided by col. 6
(1)	(2)	(3)	(4)	(5)	(6)	(7)
C_2	0.0890	0.1041	0.1931	0.1030	3.53	0.0292
C_3	0.2714	0.9770	1.2484	0.6645	1.225	0.5424
i-C_4	0.0437	0.3445	0.3882	0.2067	0.564	0.3665
C_4	0.0040	0.0445	0.0485	0.0258	0.425	0.0607
	0.4081	1.4701	1.8782	1.0000		0.9988

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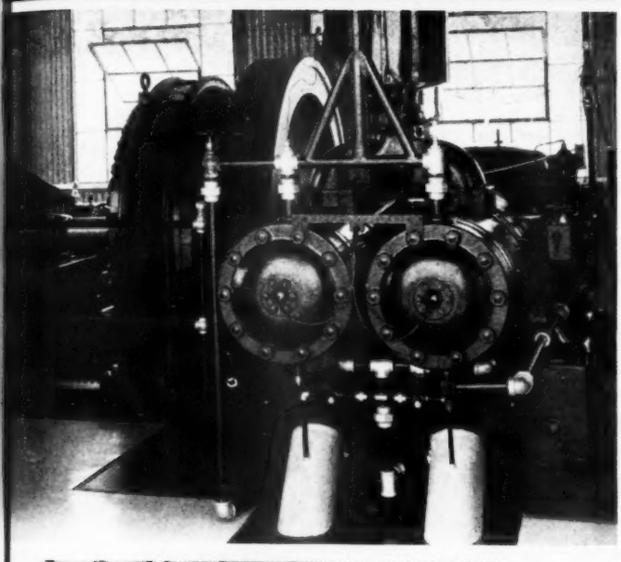

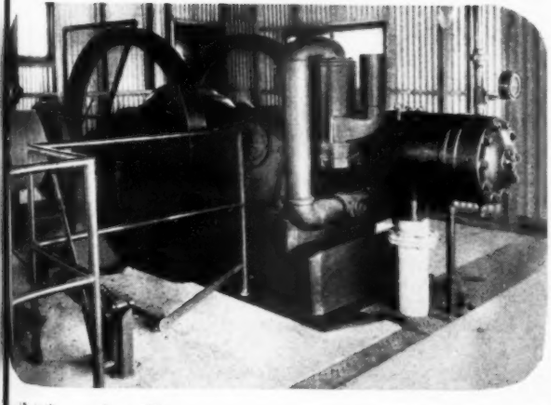

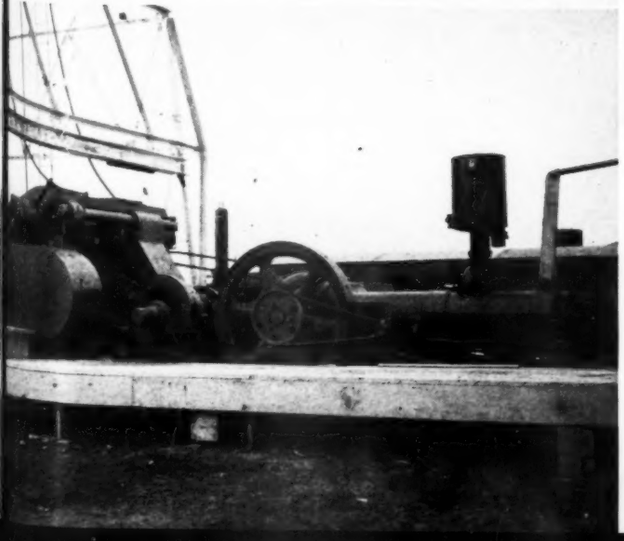

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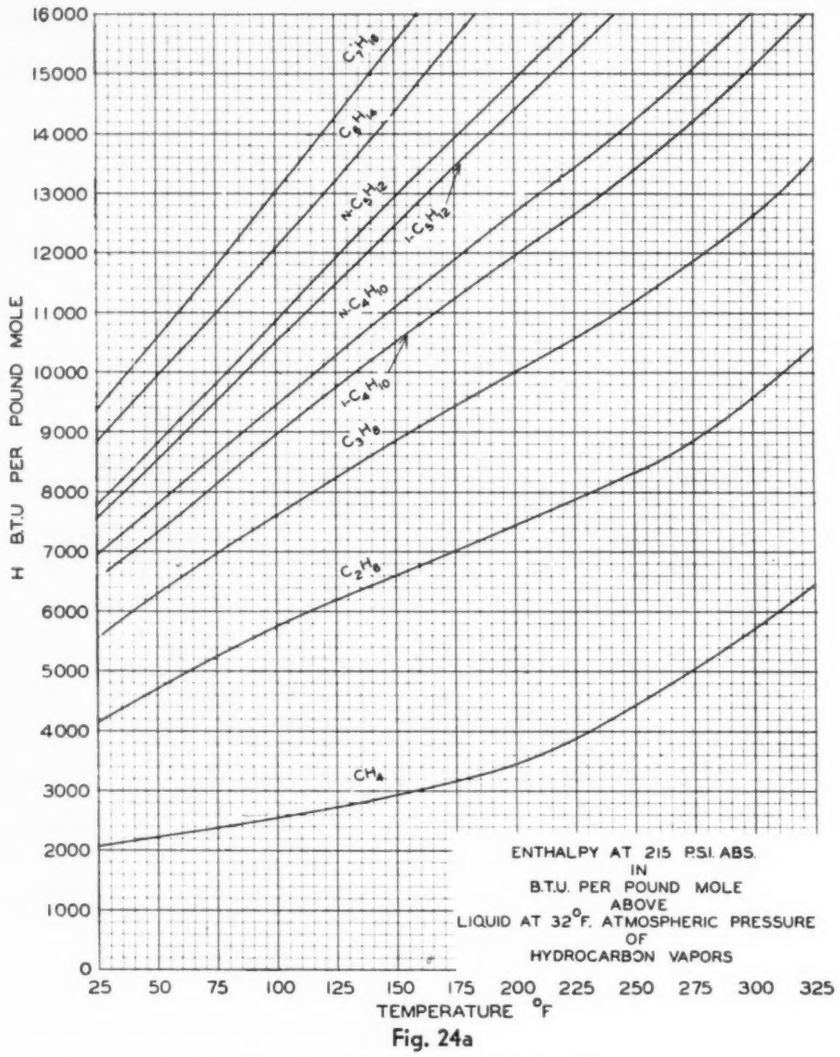

Fig. 24a

for H_3 is consistent with the composition and temperature determined for V_3.

If the value of H_3 is assumed to be 9090 B.t.u. per mole, substitution in equation (50) gives the following value of V_3.

$$V_3 = \frac{(8501)(1.878) - (2887)(0.408) - (1872)(1.47)}{9090 - 2887}$$

$$= \frac{12035}{9090 - 2887} = 1.940 \text{ moles/mole feed}$$

By material balance $L_2 = V_3 - D$

$L_2 = 1.940 - 0.408 = 1.432$ moles per mole feed

The composition of the vapors rising from the third equilibrium step, V_3, is determined by a material balance around the top of the column using the above quantities for V_3 and L_2 as indicated in Table 26. The temperature on this third step is determined by a dew point calculation as indicated in columns 6 and 7 of Table 26, and the enthalpy, H_3, per mole of vapors, V_3, is computed in the 9th column of Table 26 by multiplying the enthalpies read from Fig. 24 at the dew point of 143°F., by the mole fraction of each component in the vapors, V_3, as given in column 5.

TABLE 26

Check of assumed value for H_3

Component	D Moles per mole of feed	L_2 Moles per mole of feed	$V_3 = L_2 + D$ Moles per mole of feed	Mole fraction y_3	K at 215 lb. per sq. in. and 143°F.	Mole fraction $x_3 = y_3/K$	Enthalpy at 143°F. B.t.u. per lb. mole (Fig. 24)	H_3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
C_2H_6	0.0890	0.0445	0.1335	0.0691	3.85	0.0179	6500	449
C_3H_8	0.2714	0.8260	1.0974	0.5680	1.38	0.4110	8680	4930
$i\text{-}C_4H_{10}$	0.0437	0.5600	0.6037	0.3125	0.66	0.4730	10300	3215
C_4H_{10}	0.0040	0.0925	0.0965	0.0499	0.505	0.0990	10900	545
			1.9311	0.9995		1.0009		9139

The calculated value for H_3, 9139, is very close to the assumed value of 9090 so that the correct value, 9139, may be substituted in equation (50) for H_3 to give a new value for V_3, which will be substantially correct without the necessity of repeating the calculations given in Table 26.

Making this substitution we find

$$V_3 = \frac{12035}{9139 - 2887} = 1.925$$

moles/mole feed

$L_2 = 1.925 - 0.4081 = 1.5169$ moles/mole feed

$$\frac{L_2}{V_3} = \frac{1.5169}{1.925} = 0.788$$

This process may be continued for another plate if desired, in which case a similar process leads to the following value:

$V_4 = 1.895$ moles per mole of feed

$L_3 = 1.487$ moles per mole of feed

$$\frac{L_3}{V_4} = 1.487/1.895 = 0.785$$

If the heat balance is continued around the fourth equilibrium step, the same values for L_4 and V_5 are obtained as are indicated above for L_3 and V_4, respectively.

It is therefore concluded that an external cold reflux ratio, R/D, of 3.6 will give an internal reflux ratio, L/V, of 0.784 in the column when the external cold reflux is supplied at a temperature of 101°F. for the separation first outlined in Table 9.

A similar procedure may be used for a heat balance around the top of the column and below the feed plate to determine the values for the internal reflux ratio, $\frac{\overline{L}}{\overline{V}}$, below the feed plate. The computations are very similar and need not be expanded here.

The heat balance around the partial condenser can be made in a very simple manner using the enthalpies of Figs. 23 and 24, to determine the quantity of cooling water required as set forth in Table 27.

A similar heat balance around the reboiler and the entire column may be made for the purpose of determining the quantity of heat required at the reboiler, as set forth in Table 28.

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TABLE 27

Heat balance around partial condenser to determine cooling water requirements

Heat In per mole of feed

V_2 (Table 24, Col. 4) $\times$ H_2 (Table 25, Col. 3)

$1.878 \times 8501 = 15{,}960$ B.t.u.

Heat Out per mole of feed

R (Table 24, Col. 3) $\times$ h_R (Table 25, Col. 7)	
$1.47 \times 1872 =$	2752 B.t.u.
D (Table 24, Col. 2) $\times$ H_D	
$0.408 \times 7592 =$	3098
In cooling water by difference	= 10,110
Total	15,960

Water Required per mole of feed

Water, in 76°F., out 109°F.

Gal. water per mole of feed

$$= \frac{10110}{(109 - 76)\ 8.33} = 36.7$$

No allowance for radiation loss has been made in the overall heat balance in Table 28. There will be some loss in heat to the atmosphere and some allowance should be made for this in estimating the steam requirement.

The quantity of steam per hour and the quantity of cooling water required per hour may be obtained by multiplying the corresponding quantities per mole of feed, by the number of moles of feed supplied to the columns per hour.

NOTE: A complete set of charts giving the enthalpies (or heat content) of the light hydrocarbons is in preparation by F. J. Lockhart and will be available within a few weeks.

Correction

On page 152 of the October installment in Table 21, read equation (42) instead of (44), equation (43) instead of (45), equation (45) instead of (47) and equation (46) instead of (48).

TABLE 28

Overall heat balance to determine heat supplied at reboiler or kettle

Heat Out per mole of feed

In distillate, $DH_D = 0.408 \times 7592 =$		3098 B.t.u.
In bottoms, $Bh_B = 0.592 \times 10916 =$		6462
In cooling water		10105
	Total	19665 B.t.u.

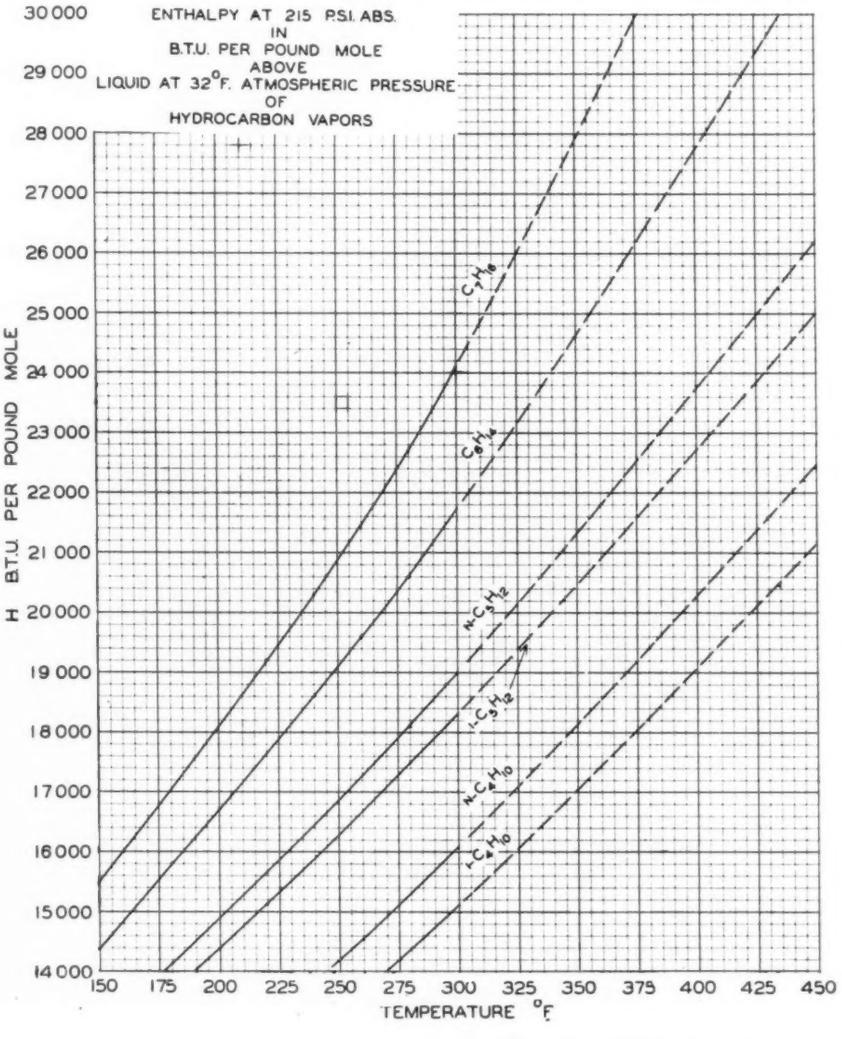
Heat In per mole of feed

In feed, $Fh_F = 1 \times 4422$	=	4422 B.t.u.
In steam in reboiler (by difference)	=	15243
	Total	19665 B.t.u.

Steam Requirement

If steam at 75 lb. per sq. in. gauge is used, the latent heat is 895 B.t.u. per lb. Assuming a quality of 95 percent at the reboiler, the steam consumption is: $\frac{15243}{895 \times 0.95} = 17.9$ lb. per mole of feed

Fig. 24b



P 773.

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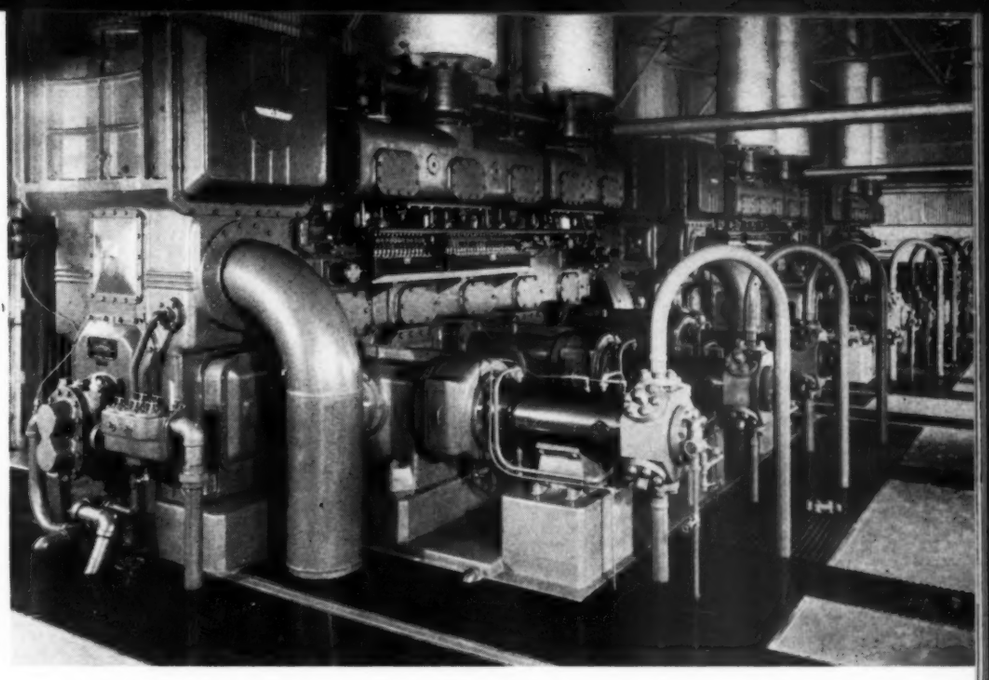

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By
HARRY WHEELDON
Assistant
General Superintendent
and
FRED H. TOWNSEND
Lone Star Gasoline
Company

Tests Determine Selection of High-Pressure Absorption Recycling Plant For Gas-Distillate Area

Optimum recovery of liquid hydrocarbons and return of extremely "dry" gas to producing formation attained by Grapeland, Texas, installation

THE Lone Star Gasoline Company and the Trinity Gas Corporation, jointly owning properties in the Grapeland gas-distillate area of Houston County, Texas, entered into an agreement in 1939 whereby Lone Star would construct and operate a recycling plant on these properties. Optimum recovery of liquid hydrocarbons and the return of an extremely "dry" gas to the producing formation that would constitute a valuable dry gas reserve for future use were the aims in mind. Before deciding upon the type of plant thought most suitable for recovering the liquid hydrocarbons from the gas-distillate, several producing wells were drilled and tests run on the production to determine the retrograde characteristics and the possible yield. Tests were first run with a mobile testing unit and later, as a check, full-scale tests were made.

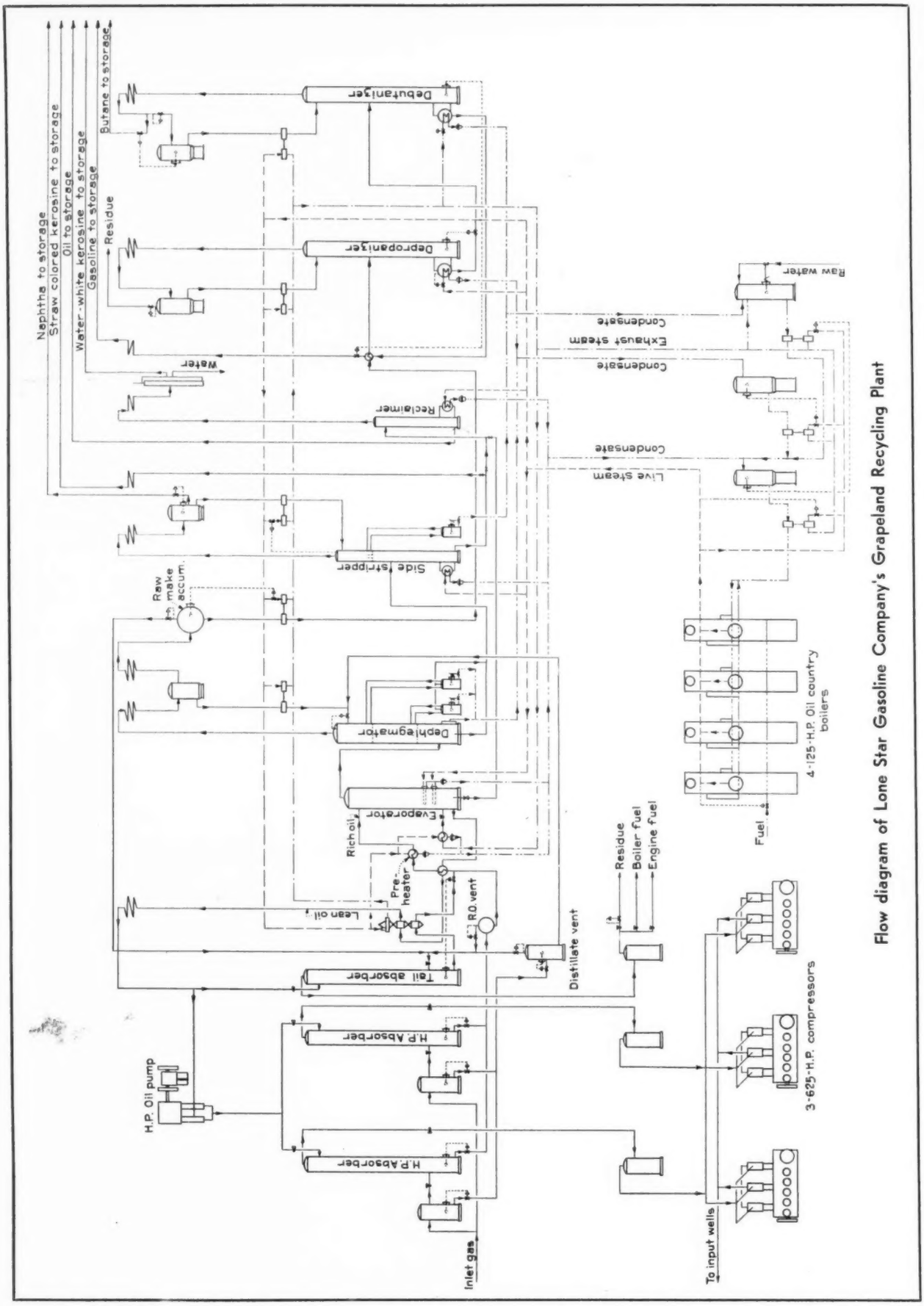
As a result of these tests it was decided that a high-pressure oil absorption-type plant would best serve requirements. Construction was begun in the spring of this year and the plant was placed in operation June 26 and has since been operating successfully. More recently additional equipment has been added to give the plant a wider scope of operation. These additions have added kerosine, butane, and an Ethyl-blended gasoline of high anti-knock value to the products originally processed. These latter units were completed in September.

HARRY WHEELDON

graduated from Texas A. & M. College in 1922 as a chemical engineer—Immediately joined the staff of the Lone Star Gas Company, working at the Petrolia plant—Subsequently was in charge of the Gainesville plant, the Petrolia plant, and the Gordon plant—When the Lone Star Gasoline Company was organized in 1931 he was placed in charge of all its West Texas plants, making his headquarters at Ranger — In 1939 he was transferred to Dallas as assistant general superintendent of the company.

FRED H. TOWNSEND

received a B.S. degree in chemical engineering from Texas A. & M. College in 1927 and went to work for the gasoline department of the Lone Star Gas Company—Was a chemist at the Gordon plant until March 1, 1932, when he was transferred to Ranger as chief chemist of the Lone Star Gasoline Company—December 1, 1933, he was made superintendent of the Gordon plant, the position he now holds—In addition to his duties there he was inspector while the Grapeland plant was being constructed.



Flow diagram of Lone Star Gasoline Company's Grapeland Recycling Plant

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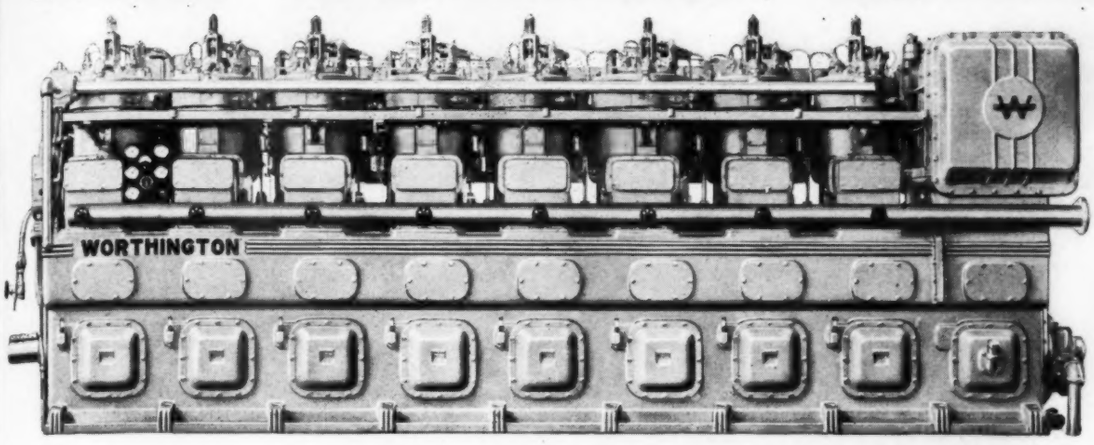

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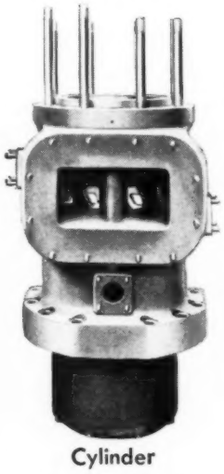

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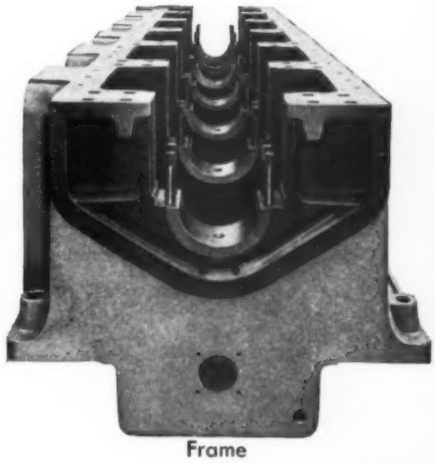

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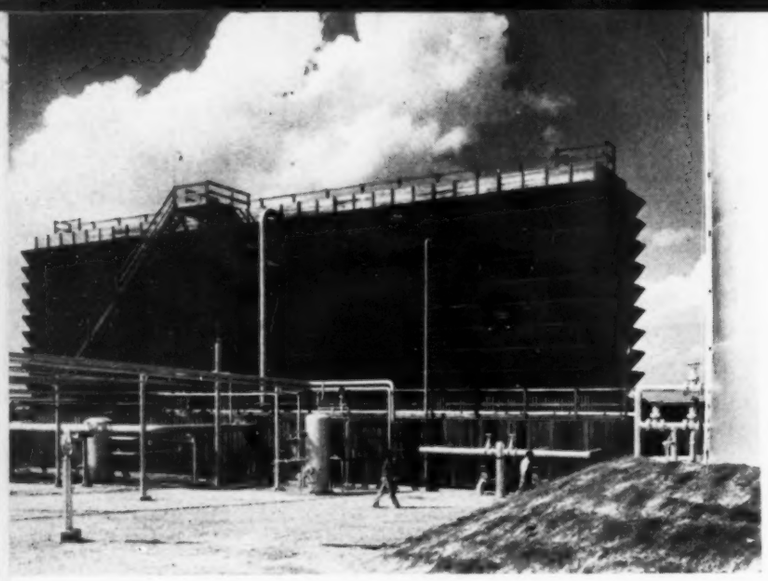


Cooling tower handling 3000 gal. of water per min.

A group of processing pumps

Make-tank and stabilizer reflux tank

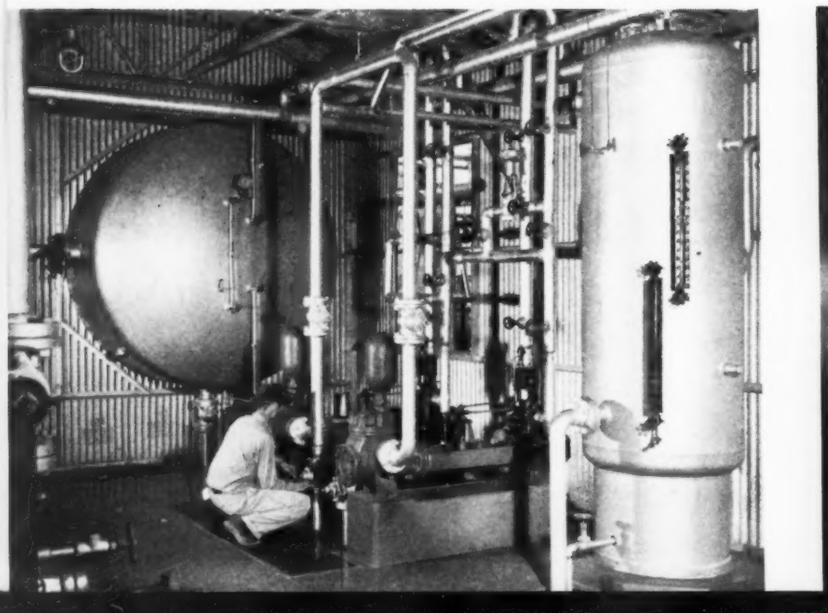
The plant has a capacity of 50,000,000 cu. ft. per day and is situated near the north limit of the producing sand. The gathering system extends to the southward and is connected to seven producing wells.

Wet gas enters the plant through a reducing regulator set to hold the desired absorber pressure of 1700 lb. per sq. in. Such liquid hydrocarbons as have condensed at this point due to temperature and pressure reduction are separated from the gas in two inlet separators. This liquid flows to a distillate vent tank where fixed gases are allowed to separate. The remaining liquid then enters the dephlegmator where it is mixed with the products recovered by oil absorption.

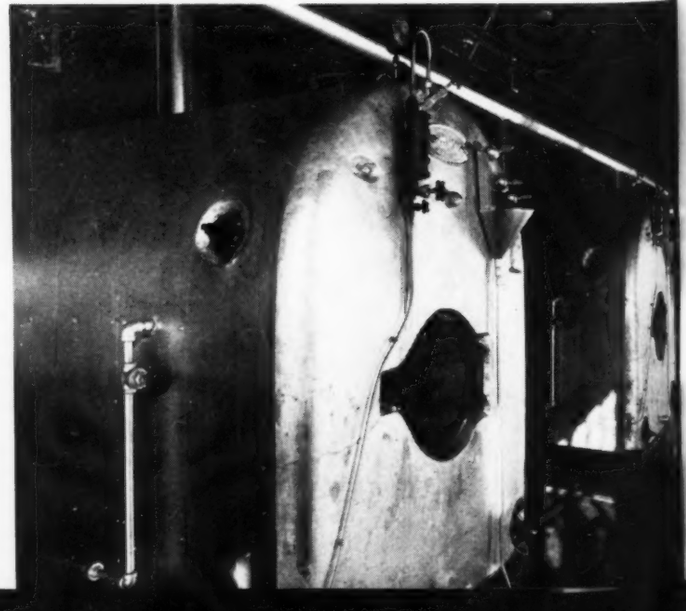
The comparatively dry gas leaving the inlet separators enters the two high-pressure absorbers, operated at plant pressure, where it is stripped of its remaining gasoline content by oil absorption. Rich oil, leaving the absorbers, goes to a rich oil vent tank to be relieved of its fixed gases.

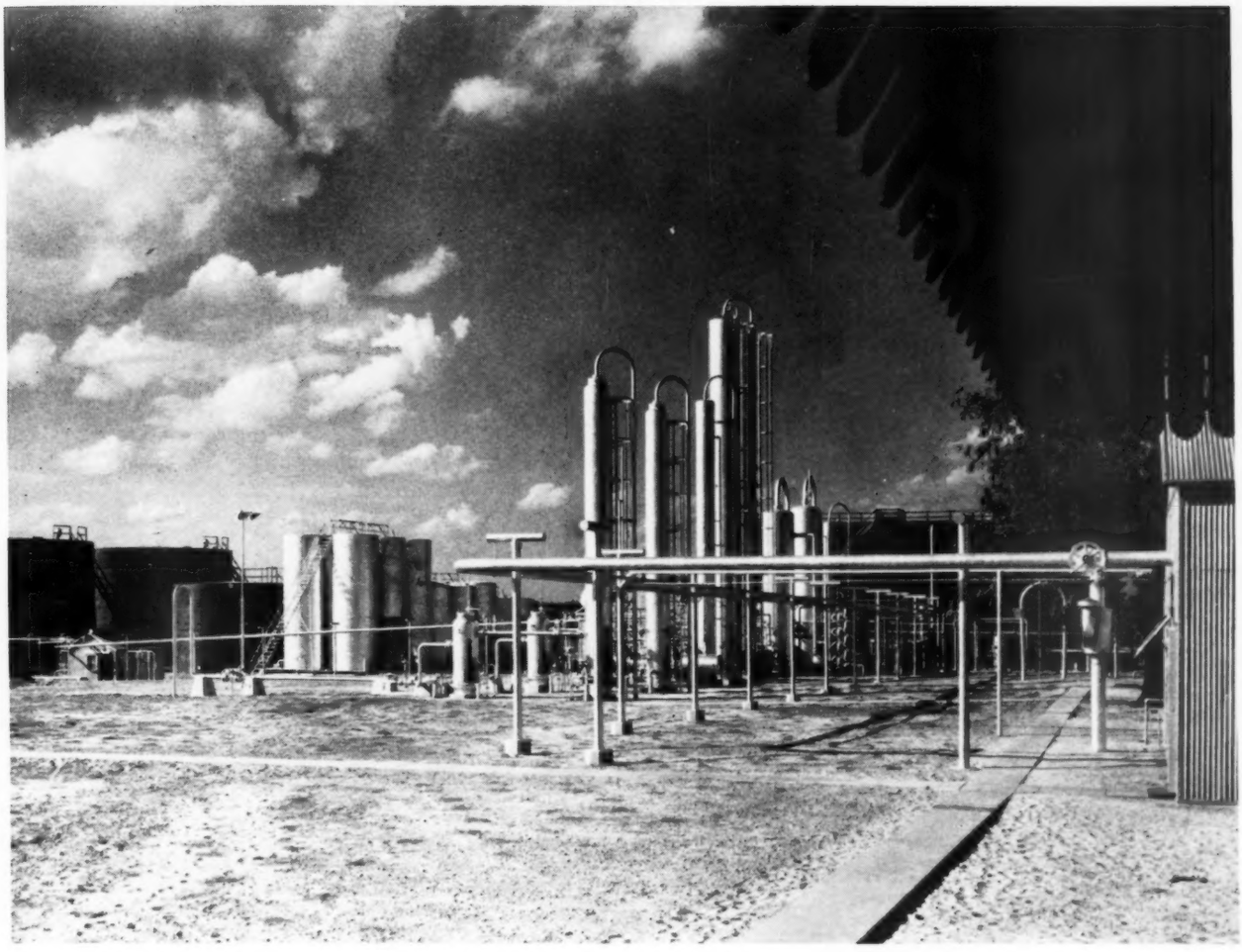
(Text Continued on Page 132)

Left—Erecting a part of the plant's tankage



Steam is provided by four 125-hp. boilers





LONE STAR GASOLINE COMPANY

and

TRINITY GAS CORPORATION

High Pressure Absorption Plant

Grapeland, Texas

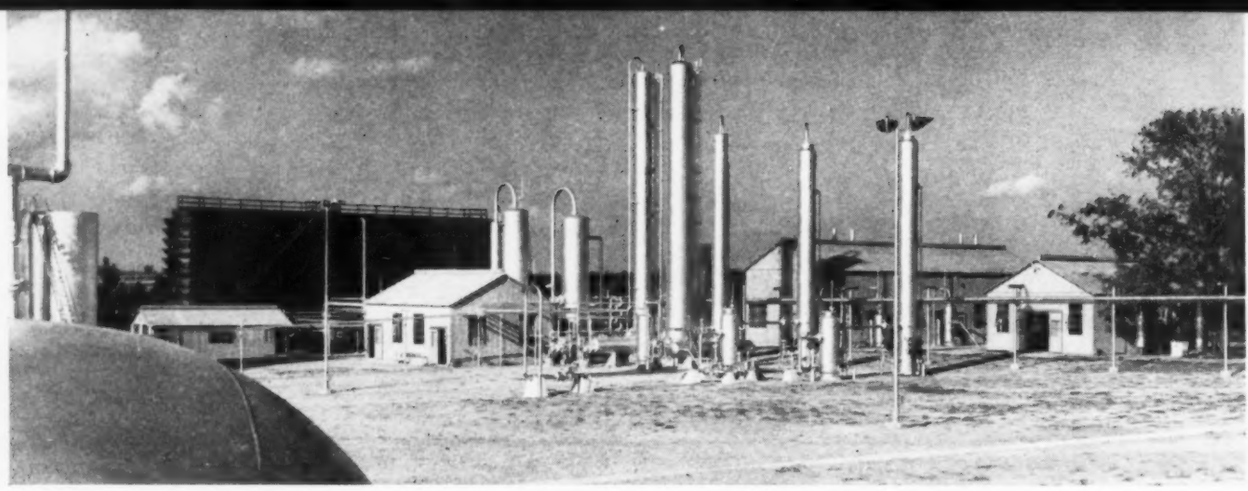
Engineered, designed and constructed

by

GASOLINE PLANT CONSTRUCTION CORPORATION

ENGINEERS 713 2nd National Bank Building **CONTRACTORS**

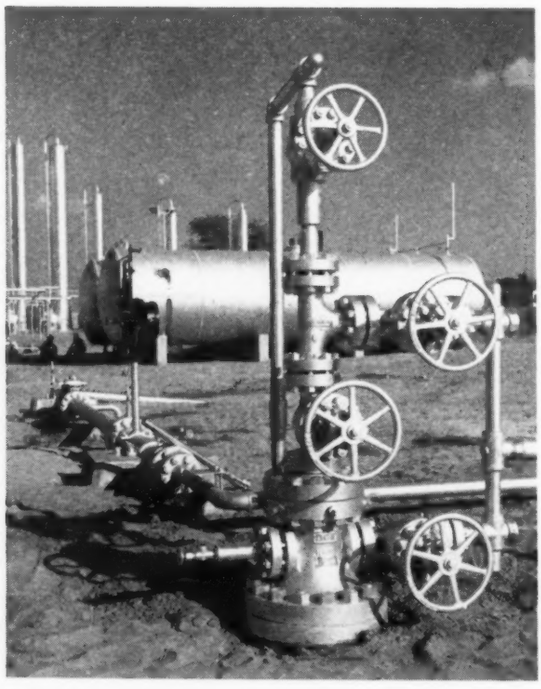
HOUSTON, TEXAS



General view of processing area of Lone Star's Grapeland Recycling Plant

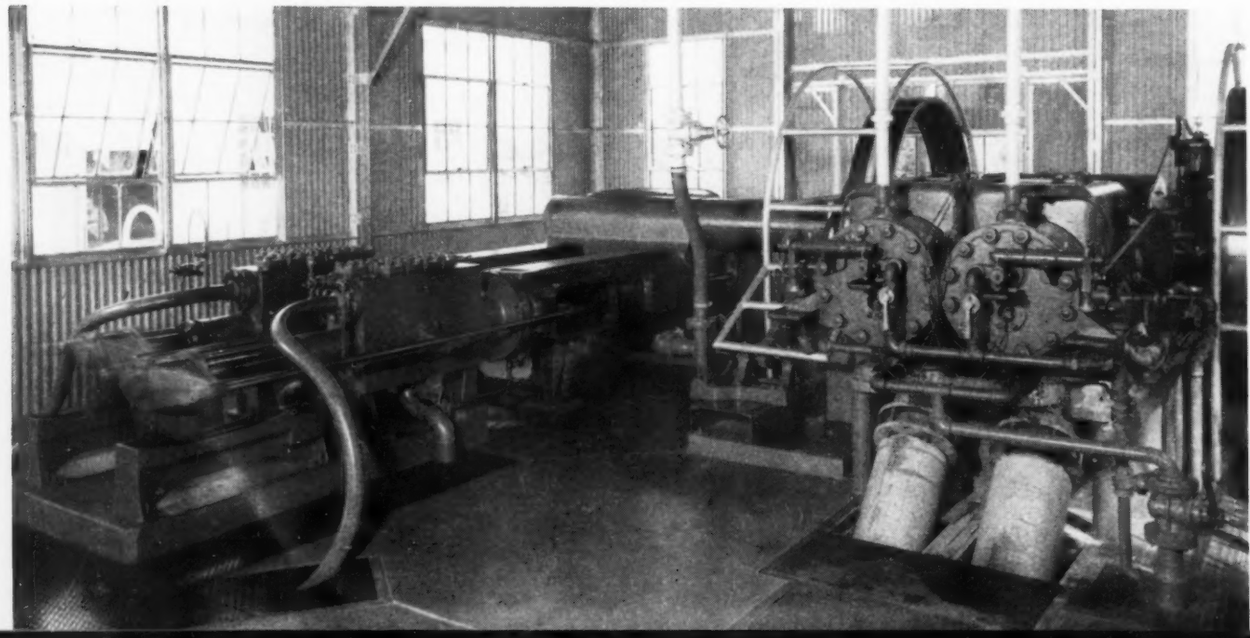
Views of Lone Star's Grapeland Recycling Plant

Main gas inlet to high-pressure scrubber



Christmas tree on an injection well

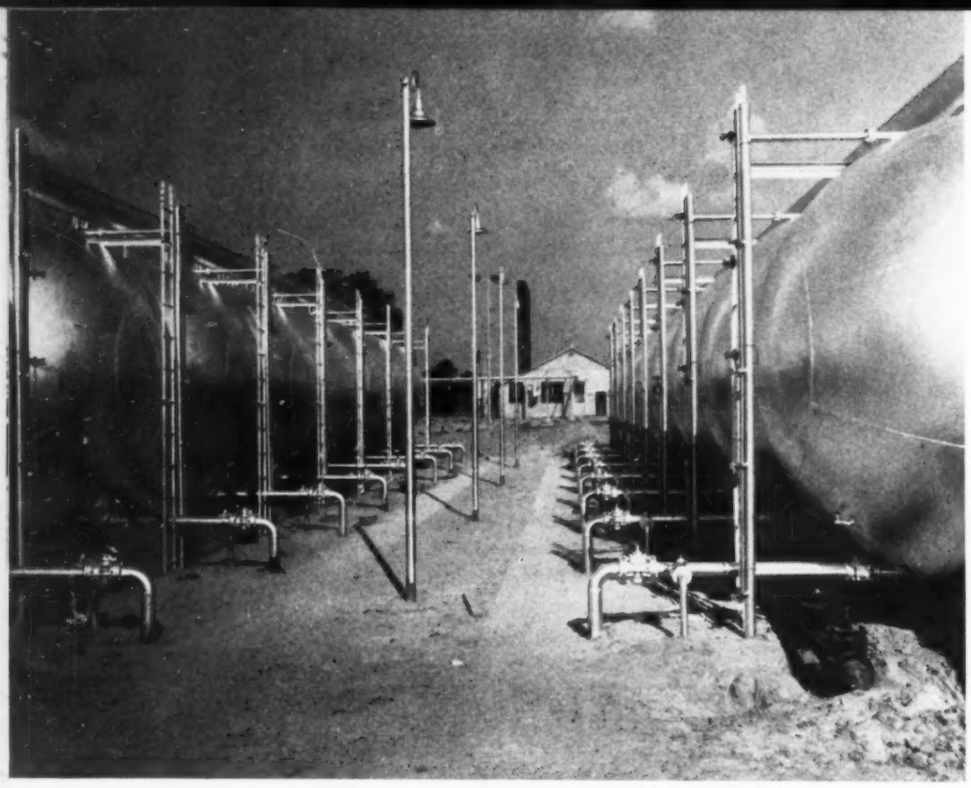
Lean oil is delivered to the system by a reciprocating pump driven by a 200-hp. gas engine



800,000 GALLONS OF FIRST LINE DEFENSE

. . . Safely Stored in API-ASME Code Pressure Tanks Fabricated by

Wyatt's



Hemispherical-head tanks for product storage

(Text Continued from Page 128)

From this point the route of the absorption oil is through heat exchangers and preheaters to the still (operated at 385-400°F. temperature) where it is stripped of its gasoline content by steam heat and agitation.

Overhead vapors from the still are taken through the dephlegmator where they are mixed with the crude distillate previously drawn from the inlet separators. A side-cut consisting predominately of kerosine is taken from the dephlegmator.

Endpoint of the products leaving the top of the dephlegmator is held slightly below 400°F. As much of the overhead from the dephlegmator as is possible is condensed in a raw gasoline make tank, from which the resulting liquid is pumped to the depropanizer where the propane and lighter hydrocarbons are removed. The resulting reboiler product is run to the debutanizer, where a 9-lb. Reid vapor pressure motor fuel, of 400°F. endpoint, is drawn-off and run to storage. The motor fuel has an octane rating of approximately 65 and the lead susceptibility is good. The overhead vapors from the debutanizer are pure butane. They are condensed and the excess in the amount required for reflux is run to the butane storage.

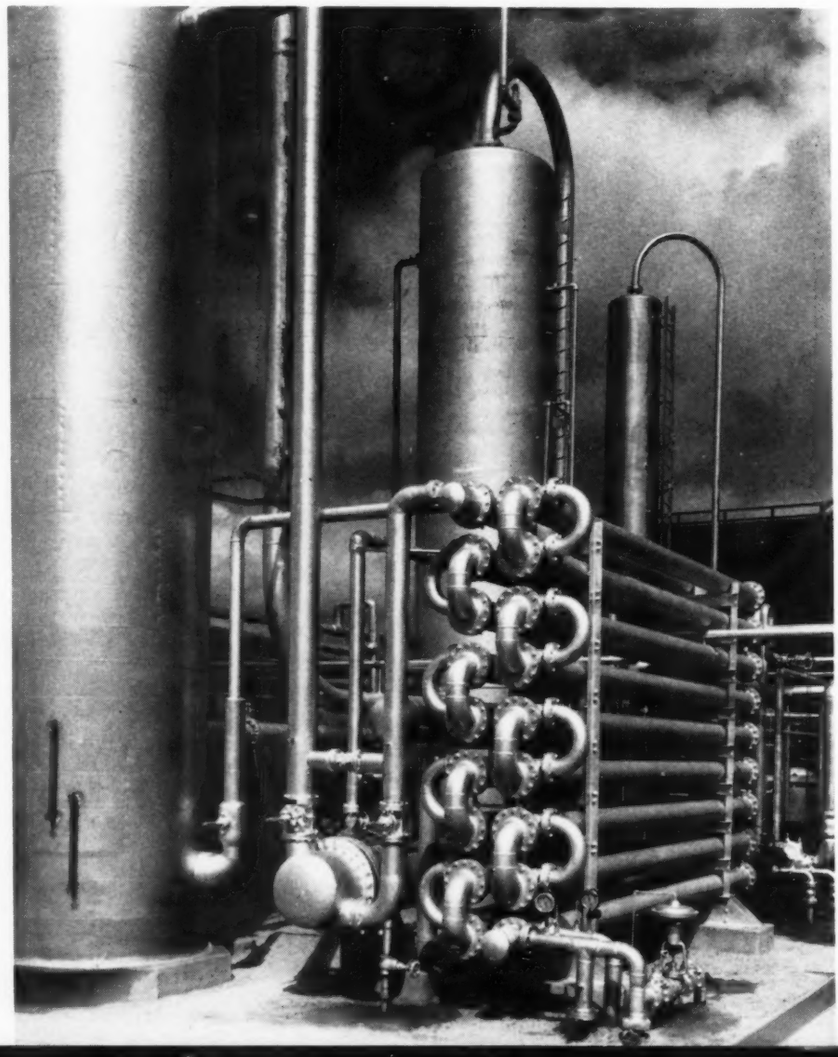
All vapors from the distillate vent tank, rich oil vent tank, and raw gasoline make tank, are reprocessed through a reabsorber operating at a pressure of 35 lb. per sq. in. In this manner no gasoline is allowed to escape from the recovery system in the form of uncondensable vapor, the residue gas from the reabsorber being practically free of any gasoline content. Fuel for the compressors, auxiliary engines, and boilers is taken from the reabsorber residue gas. Rich oil leaving the bottom of the reabsorber is pumped into the stream of rich oil leaving the high-pressure absorbers.

Hot lean oil coming off the still passes through heat exchangers and oil coolers to the suction of the lean oil pump and is returned to the absorbers for recirculation. The 3⅞-in. by 18-in. lean oil pump is driven by a 200-hp. gas engine. Lean oil is delivered to the system by this unit at a rate of 150 gal. per min. at a suction pressure of 120 lb. and a discharge pressure of 1850 lb.

Pressure Maintenance

Residue gas from the high-pressure absorbers goes through two scrubbers equipped with mist extractors on its way to the compressors, which consist of three 625-hp. angle-type units. Each unit has three compressor cylinders, of 4⅝-in. bore and 15-in. stroke. At this point the pressure of the dry gas is increased to approximately 2700 lb. per sq. in., which is sufficient for its return to the producing formation. Discharge is through an 8⅝-in. line to the two key wells situated in the north end of the field. Injection is

Still, dephlegmator, kerosine side stripper, preheater, superheater, and heat exchangers



simultaneously through casing and tubing.

A closed water system is used for cooling the compressor engines. For circulating engine jacket water, each compressor unit has a belt-driven single-stage centrifugal pump.

Steam Generation

Boilers used to generate steam for processing and to drive the steam pumps consist of four 125-hp., oilfield-type units, operated at 300-lb. pressure. All steam-driven pumps exhaust against 50 lb. per sq. in. back pressure, the exhaust steam being used for heating and steam agitation. In this manner practically all steam produced by the boilers is condensed and returned to the boilers as feedwater. This arrangement reduces feedwater make-up requirements to a minimum. General service water make-up requirements are taken from a nearby creek. To pump the water from the creek to the plant a 3-in., 2-stage pump is used, driven by a 25-hp., 440-volt induction motor, and as a standby for this service a triplex pump is provided.

Storage

Product storage is provided by sixteen 12 by 50 hemispherical-head tanks, each of which has a capacity of 40,000 gal.; two 3000-bbl. and two 10,000-bbl. vertical tanks.

Producing Wells

The seven producing wells connected to the plant are producing from the Woodbine sand found at an approximate depth of 5900 ft. Shut-in pressure is about 2200 lb.

Gathering lines consist of 3-, 6-, and 8-in. pipe, as follows: 11,850 ft. of 8-in., 0.6875 in. wall thickness, 58.28 lb. per ft.; 9500 ft. of 6-in., 0.5 in. wall thickness, 32.71 lb. per ft.; 11,000 ft. of 3-in., 0.254 in. wall thickness, 8.80 lb. per ft. Discharge lines to input wells consist of 4,000 ft. of 8-in. pipe, having 0.750 in. wall thickness and weighing 63.08 lb. per ft. All pipe had plain-end joints and was electric welded.

Cooling Tower

The cooling tower is of the atmospheric type, has 16 bays, and is 37 ft. high. Water is circulated over the tower at a rate of 3000 gal. per min. by two single-stage centrifugal pumps. One pump is direct-connected to a 25-hp., 400-volt induction motor and the other to a 30-hp., 440-volt induction motor. A standby unit consists of two single-stage centrifugal pumps direct-connected to a turbine.

Buildings

Buildings are of steel-frame construction covered with 24-gauge galvanized corrugated steel. The compressor building is 24 ft. by 84 ft. by 16 ft.; the boiler house, 24 ft. by 72 ft. by 14 ft.; the control building, 20 ft. by 36 ft. by 12 ft., and the pump house, 26 ft. by 40 ft. by 10 ft.

Power Generators

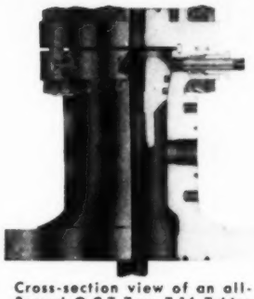
Electric power is supplied by a 94-kva. generating unit driven through V-belts by the flywheel of a gas engine.

Loading Rack

A loading rack situated approximately 8000 ft. southeast of the plant proper is provided for loading tank cars and trucks. There are 5 loading lines from the plant to the rack through which tank cars may be loaded or bulk storage at the rack may be filled.

Pumps

A complete listing of the pumps and their service follows:



Cross-section view of an all-flanged O-C-T Type T-16 Tubing Head. Tubing is suspended from a threaded type hanger which is forced into sealing position by lock-down set screws in the top flange. This head permits drilling-in and running and landing tubing through blowout preventer equipment.

O-C-T Christmas Trees, like the one pictured above on an input well of the Lone Star Gasoline Company-Trinity Gas Corporation recycling plant, are a familiar sight in the Grapeland (Texas) field. The O-C-T Type T-16 Tubing Head, shown in cross-section at left, provides the foundation for most of the O-C-T trees in this high pressure field.

Complete mechanical details on all types of O-C-T Casing Heads and Tubing Heads are provided in the new O-C-T Bulletin No. 240. Write for a copy.

OIL CENTER TOOL CO.
QUALITY O-C-T PRODUCTS
HOUSTON, TEXAS, U·S·A

Export Representative: Val R. Wittich, Jr., 30 Rockefeller Plaza, New York, N. Y.
Selling Through Leading Supply Stores

Boiler feed and condensate pumps—one 7 by 4½ by 10 simplex plunger type, one 7½ by 4 by 10 simplex plunger type, and one 10 by 6 by 12 simplex plunger type, steam-driven.

High-pressure oil pump—a 3⅞ by 18 reciprocating type having a capacity of 150 gal. per min., direct-connected to a 200-hp. gas engine.

Stabilizer feed pumps—two 10 by 6 by 12, steam-driven.

Depropanizer reflux pump — one 6 by 6 by 12, steam-driven.

Debutanizer reflux pump—one 6 by 6 by 12, steam-driven.

Dephlegmator reflux pumps—two 8 by 5 by 12 simplex piston pattern, steam-driven.

Condensate pumps—two 8 by 5 by 12 simplex piston pattern, steam-driven.

Rich oil standby pump—one 10 by 6 by 12, steam-driven.

Lean oil charge pump—one 8 by 5 by 12, steam-driven.

The main pump room also houses two skid units, each consisting of one single-stage centrifugal low-pressure lean oil pump and one 2-stage rich oil pump direct-connected to a steam turbine.

Cooling tower pumps—one single-stage centrifugal pump direct-connected to a 25-hp., 440-volt induction motor; one single-stage centrifugal pump direct-connected to a 30-hp., 440-volt induction motor, and a standby unit that consists of two single-stage centrifugal pumps connected in series to a turbine.

Engine jacket water pumps—three single-stage centrifugal pumps each belt-driven from the 625-hp. compressors, and one 3-in. single-stage centrifugal pump, belt-connected to the 200-hp. high-pressure oil pump engine.

Gasoline loading pump—one 16 by 10 by 18, steam-driven.

Kerosine loading pump—one 10 by 3 by 10 duplex, steam-driven.

Blending plant pumps—three 10 by 6 by 10 duplex, steam-driven.

Utility pump—one 6 by 4 by 6 duplex, steam-driven.

Creek water pump—one 3-in., 2-stage pump direct-connected to a 25-hp., 440-volt induction motor, and one triplex pump used as a standby unit for this service.

Butane loading pump—one 8 by 6 by 12, steam-driven.

The plant was designed and constructed by the Gasoline Plant Construction Corporation of Houston, Texas.

Principal Equipment

Major items of equipment, including the names of manufacturers, follow:

Steel buildings—Allied Steel Products Corporation.

Piston rings—American Hammered Piston Ring Division of Koppers Company.

Boilers—Broderick Company.

Temperature controls — Brown Instrument Company.

Gate valves—Chapman Valve Manufacturing Company.

Tanks—Chicago Bridge and Iron Company.

Boiler blow-off valves—Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore.

Compressor packing—C. Lee Cook Manufacturing Company.

Gas engine driving high-pressure absorption oil pump—Cooper-Bessemer Corporation.

Boiler water-level controllers—Copes Regulator Company.

Gate valves and pipe fittings—Crane Co.

Relief valves and gauges — Crosby Steam Gage and Valve Company.

Orifice meters—Foxboro Company.

Motors—General Electric Company.

Control equipment—Hanlon-Waters, Inc.

Cooling tower — Hudson Engineering Company.

Insulation—Keasby and Mattison.

Plug valves—Merco Nordstrom Valve Co.

Steam turbines—Moore Steam Turbine Co.

High-pressure absorption oil pump—National Transit Pump and Machine Company.

Christmas trees on producing and input wells—Oil Center Tool Company.

Reflex gauges—Penberthy Injector Company.

High-pressure fittings — Taylor Forge and Pipe Works.

Tube turns—Tube-Turns, Inc.

Depropanizer, dephlegmator, still, heat exchangers, low-pressure absorbers, and scrubbers—Tulsa Boiler and Machinery Company.

Air filters—Vortox Manufacturing Company.

Valves—Walworth Company.

Pipe and cooling coils—Western Supply Company.

Electric generator — Westinghouse Electric and Manufacturing Company.

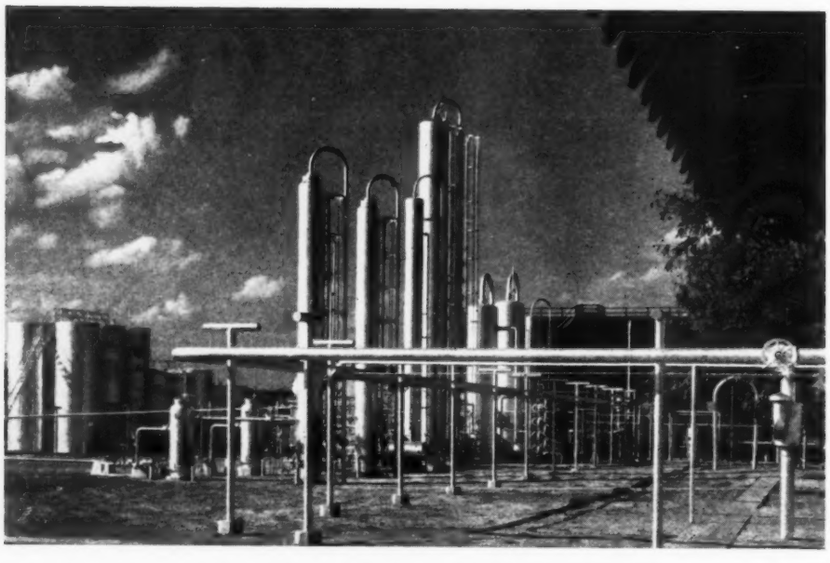
Gas compressor units and pumps—Worthington Pump and Machinery Corporation.

Tanks, scrubbers, high-pressure absorbers, kerosine side stripper, boiler feedwater heater, debutanizer, and various pressure vessels — Wyatt Metal and Boiler Works.

Boiler burners—John Zink Company.

TULSA TYPE EQUIPMENT is . . . Built RIGHT!

THAT'S WHY YOU WILL FIND it in the new Lone Star recycling plant at Grapeland, Texas



here's the TULSA TYPE EQUIPMENT installed

Evaporator
Dephlegmator
Absorber
Scrubber
Stabilizer
Preheater
Superheater
Reboiler
Heat Exchangers

PROTECTED BY THE FOLLOWING PATENTS
1,851,849 1,637,947 1,759,750 1,625,192

Tulsa Boiler & Machinery Co.
WEST TWENTY-FIRST STREET & UNION AVENUE TULSA, OKLAHOMA

Measurements of Compressibility of Consolidated Oil-Bearing Sandstones

FOR many years, studies of ground movement and subsidence accompanying subsurface mining operations have been part of the research program of the U. S. Bureau of Mines. Periodic observations by engineers of the Mining Division of the Bureau of man-built structures beneath which mining operations are conducted offer indisputable evidence of subsidence in the form of cracks in masonry structures and fractures and depressions in the surface of the earth. As the removal of subsurface rock and earth material by mining, especially by the room-and-pillar method, is equivalent to withdrawing some of the foundation of a building, subsidence of the formations above the mining levels in certain areas is easily understood as a gravitational adjustment of the overlying earth formations.

Since 1918 some evidence of subsidence of the ground surface over a few producing oil fields has been observed, leading certain engineers and geologists to believe that the weight of the earth formations overlying oil-bearing reservoirs causes a compression and compaction (reduction in volume) of the reservoir sands and rocks as oil and gas are withdrawn from them. Many oil-producing rocks are sandstones in which the quartz grains are consolidated by natural cementing materials and will not "flow" to the well with the oil. On the other hand, the friable character of cores taken from some oil-bearing rocks and the quantity of sand that may accompany the oil to the well bore in many Gulf Coast oil fields (if preventive measures are not taken) indicate that reservoir rocks in those areas may be unconsolidated or, at best, poorly consolidated sandstones. The quantity of sand brought to the surface of the ground with oil and gas, however, is a very small fraction of the total volume of the reservoir; for that reason, any analogy between subsidence of the earth formations overlying oil-producing reservoirs and subsidence in areas where underground mining operations are carried on and actual cavities are formed in the crust of the earth appears untenable.

As few experimental data on the compressibility of consolidated sedimentary rocks were available and such information seemed needed to determine the validity of certain opinions on reservoir performance, petroleum engineers of the Bureau of Mines investigated the compressibility of several sandstone cores from typical oil fields under conditions simulating those prevalent in the reservoirs, and made known their findings in Report of Investigations 3540 by Charles B. Carpenter and George B. Spencer. Among cores tested were those of Woodbine sandstone, Cretaceous age (the oil-bearing rock in the reservoir of the East Texas oil field); Bartlesville and Strawn sandstones, Pennsylvanian age; and Frio sandstone, Oligocene age.

This report is the result of the writers' study of subsidence in certain Texas Gulf Coast oil fields and the experimental work done by them to determine the reduction in volume and the compressibility of consolidated oil-bearing sandstone cores under pressures up to 8000 lb. per sq. in. The laboratory apparatus used and the procedure followed in making the tests are described in detail, and a discussion of the results of the tests is given.

ANOTHER LARGE MID-CONTINENT GAS PRODUCER*
SELECTS
VORTOX

The Standard Air Cleaner of the Industry!

VORTOX MANUFACTURING CO.
CLAREMONT, CALIFORNIA
*Lone Star Recycling Plant, Grapeland, Texas

Abstracts of A.P.I. Papers, 21st Annual Meeting . . . Chicago . . . November, 1940

DIVISION OF PRODUCTION

Factors Affecting Reservoir Performance

By R. D. WYCKOFF, Gulf Research and Development Co., Pittsburgh, Pa. Published by permission of executives of the Gulf Research and Development Co.

Factors affecting reservoir performance are considered from a broad viewpoint and in conjunction with a review of general reservoir mechanics. The interrelation of these phases of the production problem thereby is stressed. Methods of determining such factors are included only when it is considered necessary to clarify the discussion, and for this purpose only.

•

Oil Recovery by Air Drive in the Venango Fields of Pennsylvania

By PARKE A. DICKEY, Pennsylvania Topographic and Geologic Survey, Harrisburg, Pa.; ROBERT B. BOSSLER, Brundred Oil Corp., Oil City, Pa. Published by permission of the State Geologist of Pennsylvania and Brundred Oil Corporation

The secondary recovery of oil by air drive for approximately 15 years has been practiced generally in the Venango oil fields of northwestern Pennsylvania. Hitherto no attempt has been made to analyze the results and estimate the quantity of oil recoverable by this method.

The production-decline curves of properties on which no new development has taken place over a period of several years approximate straight lines on logarithmic paper. Following accepted procedure, the economic life and cumulative ultimate oil recovery of the properties thus may be predicted. Unfortunately predictions could be made for only a few of the older properties and for none of the newer developments because, on most leases, new work so affected the oil production that no conclusions could be drawn. Twelve leases showed suitable curves. The estimates of cumulative ultimate recovery range from 11 bbl. to 100 bbl. per acre-foot, with an average of 42 bbl. The economic life ranges from 9 to 48 years, the average being 28 years.

Whereas a large number of factors affects the recovery of oil by air drive, it is believed that the principal ones are the original oil and water content of the sand, the spacing of the wells, and the efficiency of the application of air to the sand. The last-named factor is seriously affected by the bypassing of air through the more permeable beds, and is difficult to take into account.

It is suggested that ultimate oil recovery and well spacing are connected by an equation of the type:

$$y = ae^{-bx^P}$$

$y = R$ = cumulative ultimate recovery, bbl. per acre-foot.

$x = F$ = square root of the product, acres per oil well times acres per air well.

$a = 140$ (a constant)

$e = 2.7183$ (base of Naperian logarithms).

Tentative values, based on the available data, were assigned to the constants.

•

API Pipe-Coating Tests—Final Report

By KIRK H. LOGAN, National Bureau of Standards, Washington, D. C.

Culminating ten years of actual service of various pipe-coating materials, this paper presents a review of the work that has been accomplished and gives the results of the final inspections.

Of particular interest are the conclusions and the expression of engineering principles related to the manufacture and use of protective coatings for pipe lines.

•

Continuous Logging at Rotary-Drilling Wells

By J. T. HAYWARD, Barnsdall Research Corp., Tulsa, Okla.

The writer discusses the development of procedure and equipment now being used successfully in detecting relatively small quantities of oil, water, and gas brought to the surface from the bottom of a drilling well by mud-circulating fluid used in rotary drilling, together with the method used in determining the depths of the horizons where the samples entered the well bore.

He describes in detail a number of instruments that have been placed upon a panel and installed in a trailer; the trailer is moved from location to location as the drilling rig is moved. Most of these instruments are concerned with the logging of the well as drilling progresses. With these new instruments and methods it now is possible to drill ahead continuously, and to know fairly accurately the type of formation that is being drilled through—its oil, water, and gas contents, and its depth. Information of this nature, obtainable while drilling, is quite helpful—not only in determining completion procedures, but also may become useful in the later life of the well in producing or reconditioning operations. Attention is drawn to the fact that *wells are drilled for the fluid contents, rather than for the rock itself.*

•

Economics of Controlling Water Produced with Oil

By J. U. TEAGUE, Hogg Oil Co., Houston, Texas

The economics of doing remedial work to exclude the water from wells producing water and oil is a problem of serious concern to the operator.

The production of water in some fields is, no doubt, injurious to the oil-producing reservoir, and should be excluded to conserve reservoir energy and increase ultimate recovery. In many other fields there is no apparent damage to the reservoir by the production of water, and any remedial work done must be justified by the saving in operating cost resulting from not having to lift the water and then dispose of it.

The principal factors that should be considered in determining the economics of remedial work are:

1. Physical characteristics of the reservoir.
2. Effect of water production on reservoir energy and ultimate recovery.
3. Means of determining the source of water.
4. Types of remedial work in common use.
5. Increased operating costs due to production of water with oil.
6. Disposal of water produced.

It is important that the statistical data and information necessary to evaluate these factors be accumulated prior to the time the production of water becomes acute and a decision on remedial work must be made.

•

Fluid-Meter Research at the University of Oklahoma

By W. H. CARSON, Dean, College of Engineering, University of Oklahoma, Norman, Okla.; E. E. AMBROSIUS, Associate Professor of Mechanical Engineering, University of Oklahoma, Norman, Okla.

The University of Oklahoma, School of Mechanical Engineering, in co-operation with the Special Research Committee on Fluid Meters of the American Society of Mechanical Engineers, for the last several years has been conducting research on meters for the measurement of oil.

The first tests were performed on inferential-type meters such as orifices, nozzles, and venturi tubes on 1½-in., 2-in., 3-in., and 4-in. lines. Diameter ratios from 0.125 to 0.84 were employed, and the Reynold's numbers ranged from 50 to 60,000. This phase of the work was begun in 1932 and is now complete. The data are in the hands of the committee, and a report is being prepared.

At present, attention is being directed toward the displacement type of meters, particularly those meters that are designed for the metering of oils. These meters range in size from 1½ in. to 6 in. Meter-accuracy tests are made at the University of Oklahoma, where special equipment is available. With this equipment it is possible to vary the rate of flow through any meter from about 5 percent to 125 percent of its rated capacity, the maximum rate of flow being 450 gal. per min. During the tests the medium-grade oil in the system was heated by suitable heat exchangers, thus varying its viscosity. Thus information is obtained on viscosity and temperature effects. To insure accuracy the meter readings were taken with the aid of a camera.

The results of the volumeter research show the general characteristics of the meters to be as follows: *a*, slip in sealing; *b*, pressure-slip relationship; *c*, mechanical and hydraulic friction; and, *d*, pressure drop resulting from fluid friction and in driving metering parts.

•

Hydraulics of Mud-Circulating Systems

By WESLEY W. MOORE, Tulsa, Oklahoma

This discussion does not relate to mud control nor mud conditioning, about which much already has been published. It deals rather with a preliminary analysis of the problem of circulating an average rotary-drilling mud down to and back up from the bottom of the well bore in such volume and at such velocity as effectively to remove drill cuttings from the face of the formation being contacted by the drill bit and to transport such cuttings to the surface, where they can be deposited.

The useful work accomplished by the circulating mud stream is normally very small in relation to the energy expended. Much of the hydraulic energy, supplied by the slush pump, is consumed by friction head within the drill pipe; whereas no useful work is accomplished by the mud stream until after it has left the drill bit. In most instances the overall mechanical efficiency of the mud-circulating system can be improved by closer attention to the relationship of hole diameter, drill-pipe size, and slush-pump capacity. Included with this paper are charts and tables that it is believed may assist in analyzing the problem here introduced.

DIVISION OF REFINING

The Naphtha Polyform and Gas Reversion Processes

By J. E. BOGK, Phillips Petroleum Co., Bartlesville, Okla.; P. OSTERGAARD, Gulf Oil Corp., Pittsburgh, Pa.; and E. R. SMOLEY, The Lummus Co., New York, N. Y.

Presented by Mr. Smoley

High yields of motor fuels with CFR-ASTM octane numbers of from 70 to 80 are obtained from gas reversion and polyform operations. Theoretical discussion of improved gas-naphtha conversion results obtained in these processes is presented. Cooperation is obtained with mixed propanes, butanes, and naphtha; and polymerization, alkylation, and other synthesis reactions take place. The dilution of naphtha with gases has a pronounced physical effect on naphtha reforming, permitting increased conversion per pass with less tendency towards coke formation. Commercial application, operating flow sheets, and data from polyform and gas reversion units are presented. Equipment and operation of these units, as well as the distillate treating, are conventional and similar to thermal cracking. Commercial operations extend over 4 years, with 10 units now operating and 2 units under construction, which altogether will process 55,000 bbl. per day of naphtha and outside propanes and butanes. The polyform and gas reversion processes give increased yield and increased octane number, and the gasoline produced has good distillation characteristics and lead response. Investment and operating-cost curves presented with this paper provide means for obtaining economic realizations. These show one- to two-year payoff on investment, and demonstrate that these refining methods have a place in the petroleum industry.

•

Heavy-Duty Motor Oils

By H. C. MOUGEY, General Motors Corp., Detroit, Mich.

With improvements in engines, fuels, and roads, the service requirements on gasoline and Diesel engines are increasing rapidly. This

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by LESTER C. UREN

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means that the lubricating oils should be able to lubricate the engines under the heavy-duty service conditions that are becoming more common.

In order to meet these requirements, the lubricating oils should be resistant to oxidation or chemical decomposition in the crankcase; the oil must not be corrosive to engine parts; the products of thermal decomposition in the combustion chamber should not be excessive; and the oil should be of such a nature that the decomposition products that get into the oil will not adhere too strongly to pistons, rings, or other engine parts.

Oils and fuels are just as much parts of the engine as pistons and crankshafts. Progress in engines and progress in oils and fuels must go hand in hand, and neither the oil nor automotive industry can make much progress by itself, or if progress lags behind in the other industry.

These desirable results can be obtained by the oil and automotive industries at the present time.

•

Use of Azeotropic Distillation in Separating Hydrocarbons from Petroleum

By FREDERICK D. ROSSINI, National Bureau of Standards, Washington, D. C.; Director of API Research Project 6; BEVERIDGE J. MAIR, Research Associate, API Research Project 6, at the National Bureau of Standards; AUGUSTUS R. GLASGOW, JR., Research Fellows, API Research Project 6, at the National Bureau of Standards.

Presented is a brief discussion of azeotropic distillation, including the principles involved, the substances that form azeotropic mixtures with hydrocarbons, the separation of hydrocarbons by azeotropic distillation, the benefits of prior distillation at reduced pressure, the separations obtainable, and mention of some commercial applications.

•

Fuel-Quality Requirements as Affected by Items of Motor Maintenance

By H. M. TRIMBLE and K. C. BOTTENBERG Phillips Petroleum Co., Bartlesville, Okla.

A number of items of motor maintenance, which exert an influence on fuel-quality requirements for trouble-free operation, are listed and discussed. Such items appear to fall logically into two classes, viz., those which contribute to place restrictions on the volatility characteristic of fuels, and those which contribute to determine required anti-knock characteristics.

A series of road tests on 18 cars is reported, in which the effects of various maintenance items on octane requirements were investigated. Average octane requirements of the cars, before and after the corrective measures and adjustments, were found to be 71.4 and 62.7 octane numbers, respectively, a decrease of 8.7 octane numbers. A reduction of 9 octane numbers was traceable to the removal of accumulated carbon deposits. The data show no definite relationship between octane-number-requirement decrease and miles driven since last carbon removal.

The magnitude of the effect of carbon deposits on octane requirements appears to warrant more attention on the part of car owners to applying the maintenance necessary to decrease a rapid buildup of deposits.

•

Use of Lecithin in Gasoline

By H. V. REES, W. S. QUIMBY, and J. C. D. OOSTERHOUT, The Texas Co., New York.

Lecithin, obtained from soybeans, is a phosphatide found to be effective in improving leaded and unleaded gasoline quality and stability. It has little effect on initial or dark storage color, but markedly reduces decolorization as well as haze and deposit formation when exposed to sunlight, as in gasoline-dispensing pumps. Its use results in decreased corrosion of storage-tank bottoms and of galvanized drums, particularly those containing highly leaded aviation gasolines in which the formation of zinc-oxide deposits often requires filtration prior to consumption. Reduced aluminum corrosion in aviation-gasoline tanks due to moisture condensation also was found. Dosages required range from 1 lb. to 15 lb. per 1000 bbl.

A Comment on the Viscosity Classification of Lubricants

By W. S. JAMES, The Studebaker Corp., South Bend, Ind.

This paper discusses the confusion that results when SAE viscosity classifications for motor oils and for transmission and rear-axle lubricants are plotted on ASTM viscosity-temperature charts.

Several charts are given, illustrating the present confusion, and the author then suggests that a viscosity classification should be worked out in which there is much less overlapping of ranges at the more commonly-used temperatures.

•

Synthetic Chemicals from Petroleum

By L. ROSENSTEIN, Shell Chemical Co., San Francisco, Calif.

The manufacture of synthetic chemicals from petroleum and natural gas has been one of the major developments in the chemical industry during the last decade. As an example, Shell Chemical Company's production of ammonia has increased from 4,500 tons in 1931 to 27,000 tons in 1939; of solvents from 90,000 lb. to 57,000,000 lb. in the same period. A continually increasing variety of chemicals of exceptionally high purity is being made available at constantly decreasing cost, from cheap raw materials whose supply is stable, abundant, and remarkably adaptable. Alcohols, ketones, and esters made from refinery gases that formerly were used only as furnace fuel now are known quite well to chemical markets. Many new products, now produced on laboratory and pilot-plant scale by Shell Development Company, in due course will join them. Among these are unsaturated alcohols and chlorides, glycerol and its derivatives, and butadiene.

The entrance of the petroleum industry into the field of synthetic chemicals has had a profound influence upon the development of synthetic gasolines; thus the development of *iso*-octane was associated closely with that of secondary butyl alcohol. Other similarly close relationships may be expected as petroleum chemicals play an increasingly important part in the economics of the industry.

•

The Emulsion De-oiling Process

By A. H. SCHUTTE, The Lummus Co., New York, N. Y.

This paper presents a new process for de-oiling crystalline waxes, and summarizes the pilot-plant and commercial operations. The process utilizes water emulsions to effect continuous wax-oil separations. No expensive solvents nor solvent-recovery equipment is required. The processing time is a matter of minutes, rather than of days; and, therefore, automatic control is immediately effective. The plant cost and operating cost are low, and only exhaust steam is required for heating. The method may be applied to the complete processing of slack wax to semi-refined grades, or may be used as an adjunct to existing sweating equipment.

The emulsion wax-separation processes are covered by the following U. S. Patents issued to Schutte: No. 2,168,140, 2,168,141, 2,168,142, 2,168,143, and 2,168,306 and pending applications for patent. The Lummus Company is the sole licensor.

•

Engine Performance as Influenced by Ignition Timing Maintenance

By R. J. Greenshields and L. E. HEBL, Shell Oil Co., Inc., Wood River, Ill.

It is recognized generally that the best performance for which an engine can be designed is limited by the anti-knock value of the fuels available. The attainment of this peak performance requires a delicate combination of spark timing and compression ratio; consequently, the continued maintenance of that adjustment of the timing mechanism which the engine designer intended to be used is necessary if best performance is to be expected.

The accumulated information indicates that timing mechanisms of a small percentage of cars are allowed to become advanced in service, so that the octane requirements of those cars are increased sufficiently to cause present-day fuels to knock, with no improvement in engine performance. An even larger percentage of cars has been found to operate with the spark timing retarded excessively, causing definite reduction in performance.

Although the importance of correct spark timing has become common knowledge through the co-operative studies of various groups, it can be likened to the weather, concerning which Mark Twain once said that nobody ever does anything about it. Greater care in maintenance of correct timing not only would ensure improved performance with present-day fuels—it also would reduce the number of cases in which detonation is obtained with today's fuels.

•

Trends in Automobile Design Match Evolution in Fuels

By T. A. BOYD and W. G. LOVELL, Research Laboratories Division, General Motors Corp., Detroit, Mich.

The trends toward greater comfort and better appearance, lower cost, higher power, and more miles per gal., which have been sustained for many years in the automobile industry, largely have paralleled the evolution in fuels. In particular, the upward trend in octane number has helped in putting more performance and economy into cars year by year. Thanks to more volatile gasoline, also, automobile engines have been made to breathe more freely and to breathe cooler air. Mixture ratios, too, have been made leaner. The advances achieved year by year in fuels in cars thus have been made to supplement one another in such a way as to yield better products, and at distinctly lower costs. Looking to the future it seems reasonable to expect that this mutual evolution will be continued as further advances permit.

AUTOMOTIVE TRANSPORTATION

Protection Against Static Electricity

By J. M. PEARSON, Sun Oil Company, Philadelphia, Pa.

Following a brief discussion of the essential difference between a **spark** and an **arc**, an analysis is given of specific conditions under which static electricity is a definite hazard in the petroleum industry.

As the rubber tires on a truck roll over the pavement, electrical pressure of 2,000 to 15,000 volts drives small currents to the truck body, that may accumulate and be discharged with disastrous results unless grounded by a drag chain.

In filling tanks, large and small, the hazardous accumulation of static currents on the free oil surface may be prevented by discharging at the tank bottom.

Other static hazards mentioned are: (1) lightning; (2) static charges on workmen; (3) static on customers' automobiles (in filling stations), and (4) belt-driven equipment.

•

Should Gross Vehicle-Weight Limitations Be Made Universal?

By J. W. SINCLAIR, Union Oil Company of California, Los Angeles, California.

Trade barriers resulting from the lack of uniformity in state requirements as to gross vehicle weights are discussed. The question propounded in the title of the paper is considered pro and con. The writer questions that national unity respecting vehicle weight limitations is immediately desirable and suggests that "any regulation should avoid the imposition on all areas of any requirement calculated to meet a condition in only one area." The first step toward national unity, the writer says, is uniformity in major regional zones, a step that will be productive of the smallest degree of economic disturbance.

•

Safe Motor-Vehicle Transportation in Oil Fields

By R. B. ROAPER, Humble Oil and Refining Co., Houston, Texas.

The oil industry is a comparatively new industry that embodies still a definite and newer department—oil-field transportation. From the days of the oxen teams to the modern tandems, this department constantly has improved methods to result in better work and fewer injuries to personnel. Only in the last six or seven years has concentrated and directed planning been applied to oil-field transportation; yet this brief study has produced results that not only have kept pace with the entire petroleum industry, but which offer splendid prospects for more efficient and safer operations in the future.

P 773.7

Acetylene welders cutting fittings to make connections in construction of Sunflower plant

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
J. C. ALBRIGHT

Gasoline Plant in Salem Field Expands Facilities

Gasoline content of gases from three producing zones prompts addition of four 230-hp. compressors and other processing equipment

AS the gas produced with oil from all formations in the Salem, Illinois, field contains relatively large quantities of easily separated hydrocarbons suitable for the manufacture of natural gasoline, Sunflower Natural Gasoline Company has rebuilt and added to the facilities of its plant in section 16 of Salem Township. The initial stages of this plant were set soon after the large Devonian production was obtained by Kingwood Oil Company last October on its Shanafelt lease, to process gas under well or separator pressure. Subsequent developments and conditions in this field determined that gas-engine-driven compressors be installed to handle the gas at approximately atmospheric pressure at the traps and flow tanks.

Vital changes affecting the operation of this plant were begun early in July, 1940, with Anson W. Dwen in charge of installing the equipment and putting the plant in condition to manufacture the maximum quantity of 26/70 natural gasoline and later to install auxiliary towers and columns to produce liquefied petroleum gases, principally a mixture of propane and butane for industrial and domestic use.

The gas produced in the field surrounding the plant site comes from three principal formations. The shallowest of these formations is the Benoist sand, which has been quite productive in many sections of Illinois, found at a depth of about 1765 ft., running about 35 ft. thick, but varying considerably from this average figure. This gas is the lowest in volume of the three formations, considered on the basis of oil ratios at the wells, perhaps because the Benoist wells have been producing longest. The liquefiable fractions of the Benoist gas are intermediate between the gases derived from the McClosky lime and the Devonian, or Salem lime, the other two producing formations. The composition of Benoist gas is shown in the result of a Podbielniak low-temperature fractional distillation:

Sample of Benoist gas from Kingwood Oil Company's A. Shanafelt No. 6

Fraction	*Percent*
CO_2	0.00
Air	0.00
Methane	59.78
Ethane	19.21
Propane	12.75
Butane	5.80
Pentane plus	2.46
Total	100.00
Content in gal. per M. cu. ft.	
Propane	3.45
Butane	1.87
Pentane plus	1.01
Possible recovery	6.33

J. C. ALBRIGHT

was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921— With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer—For last 11 years has devoted virtually all his time to free-lance writing for trade journals.

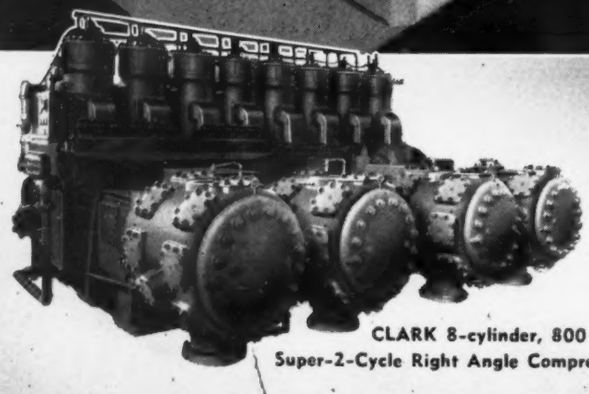
McClosky lime wells were drilled almost immediately following the discovery of shallow production, but this production declines quickly. The McClosky has a reputation for longevity, however, as wells have been producing oil from the LaSalle Anticline in eastern Illinois for more than 30 years. This lime is found at about 1935 ft. below the surface at Salem and the gas produced has the follow-

(Continued on Page 142)

CLARK 800

in new combination Gasoline P

Rear View CLARK 8-Cylinder, 800 H.P. "Angles" in El Paso Natural Gas Co. plant, at Jal, New Mexico.



CLARK 8-cylinder, 800 H.P. Super-2-Cycle Right Angle Compressor.

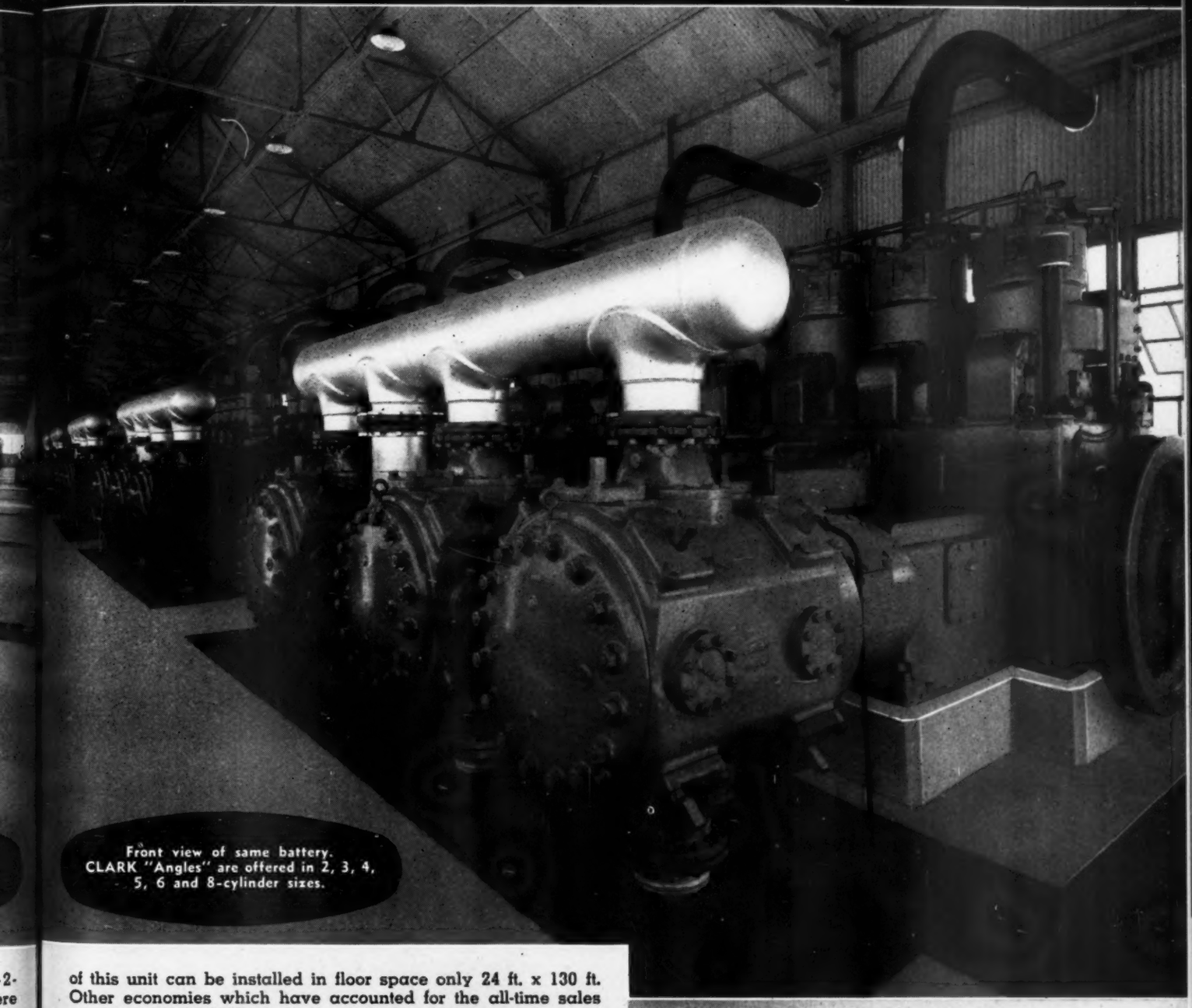
FIVE of the new 8-cylinder, 800 H.P. size CLARK Super-2-Cycle "Angle" Compressors — totalling 4,000 H.P. — were ordered and are now in service in the new combination gasoline plant and gas booster station of the El Paso Natural Gas Company, at Jal, New Mexico.

Built by the construction department of the El Paso Natural Gas Company, this new plant is one of the largest of its kind in the industry, having been designed to handle a maximum of 85,000,000 cu. ft. of gas daily. It takes gas from the wells at 19.2 lbs. pressure, strips the gasoline from it, and puts it into the trunk pipe line at 562.2 lbs. pressure.

The CLARK "Angle," due to new features and compact design, introduced several important economies. The new 8-cylinder unit represents a still further gain in compactness. 4,000 H.P.

H.P. "ANGLES"

ePlant and Gas Booster Station



Front view of same battery. CLARK "Angles" are offered in 2, 3, 4, 5, 6 and 8-cylinder sizes.

of this unit can be installed in floor space only 24 ft. x 130 ft. Other economies which have accounted for the all-time sales record of the CLARK "Angle" are: Reduced transportation and erection costs, due to shipment assembled; saving of one-third in fuel due to CLARK Fuel injection and 26% excess scavenging air; lowest maintenance due to simplicity of design.

Before selecting your next compressors allow us to fully explain the economies which have sold 200,000 horsepower of CLARK "Angles" in only 4 years.

CLARK BROS. CO., INC. . . . OLEAN, NEW YORK, U.S.A.

Export Offices: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill.; Boston, Mass. (131 Clarendon St.) West Coast Offices: Smith-Booth-Usher Co., Los Angeles, Cal. Foreign Offices: 72 Turnmill St., E. C. 1, London; 4 Str. General Poetas, Bucharest, Roumania.

CLARK

Four 230-hp. horizontal gas engines being set on their foundations

(Continued from Page 139)

ing composition as shown by a Podbielniak low-temperature fractional distillation:

Sample of McClosky gas from Kingwood Oil Company's A. Shanafelt No. 9	
Fraction	*Percent*
CO_2	0.00
Air	1.17
Methane	40.42
Ethane	23.00
Propane	20.96
Butane	9.50
Pentane plus	4.95
Total	100.00
Content in gal. per M. cu. ft.	
Propane	5.67
Butane	3.06
Pentane plus	2.03
Possible recovery	10.76

The deepest production to date in Salem is that coming from the Devonian, sometimes called the Salem lime, which was discovered in the Salem field by Kingwood in October, 1939. The Devonian is found productive over a considerable area beneath the Benoist and McClosky and is responsible for the large flush production in both Salem and the Centralia oil fields during the first half of 1940. It is, in the parlance of the driller, a "bug-hole" lime, full of cavities and honeycombs where *crustaceans* were either fossilized or disintegrated when the formation was being laid down. The amount of gas produced from the Devonian is many times more than several gasoline plants could process, most of which is being burned through vent lines or flares from oil and gas separators. The quality of this gas is shown below, in the results of a Podbielniak low-temperature distillation analysis:

Sample of Devonian gas from Kingwood Oil Company's A. Shanafelt No. 18	
Fraction	*Percent*
CO_2	0.00
Air	4.10
Methane	66.75
Ethane	15.42
Propane	7.92
Butane	3.39
Pentane plus	2.42
Total	100.00
Content in gal. per M. cu. ft.	
Propane	2.14
Butane	1.09
Pentane plus	0.99
Possible recovery	5.22

Natural gasoline manufactured in Illinois has the advantage over that coming from Group 3 and Texas as it is close to large refining centers, such as Wood River, East Chicago, and other refineries in Illinois and Indiana. Liquefied petroleum gases are not produced in quantities in Illinois sufficiently large to do much more than supply local demand. Several good-sized towns in the vicinity of the Illinois fields have been equipped with liquefied gas systems in lieu of natural gas, and any plant situated east of the Mississippi River undoubtedly can dispose of all production to advantage within the immediate vicinity.

The expansion program recently completed in the Sunflower plant consists of four 230-hp., horizontal, twin gas engines driving direct-connected compressors equipped with 18-in. cylinders, having a combined capacity of about 11,000,000 cu. ft. of gas per day, when received at or near atmospheric pressure and compressed in one stage to 50 lb. per sq. in. gauge pressure.

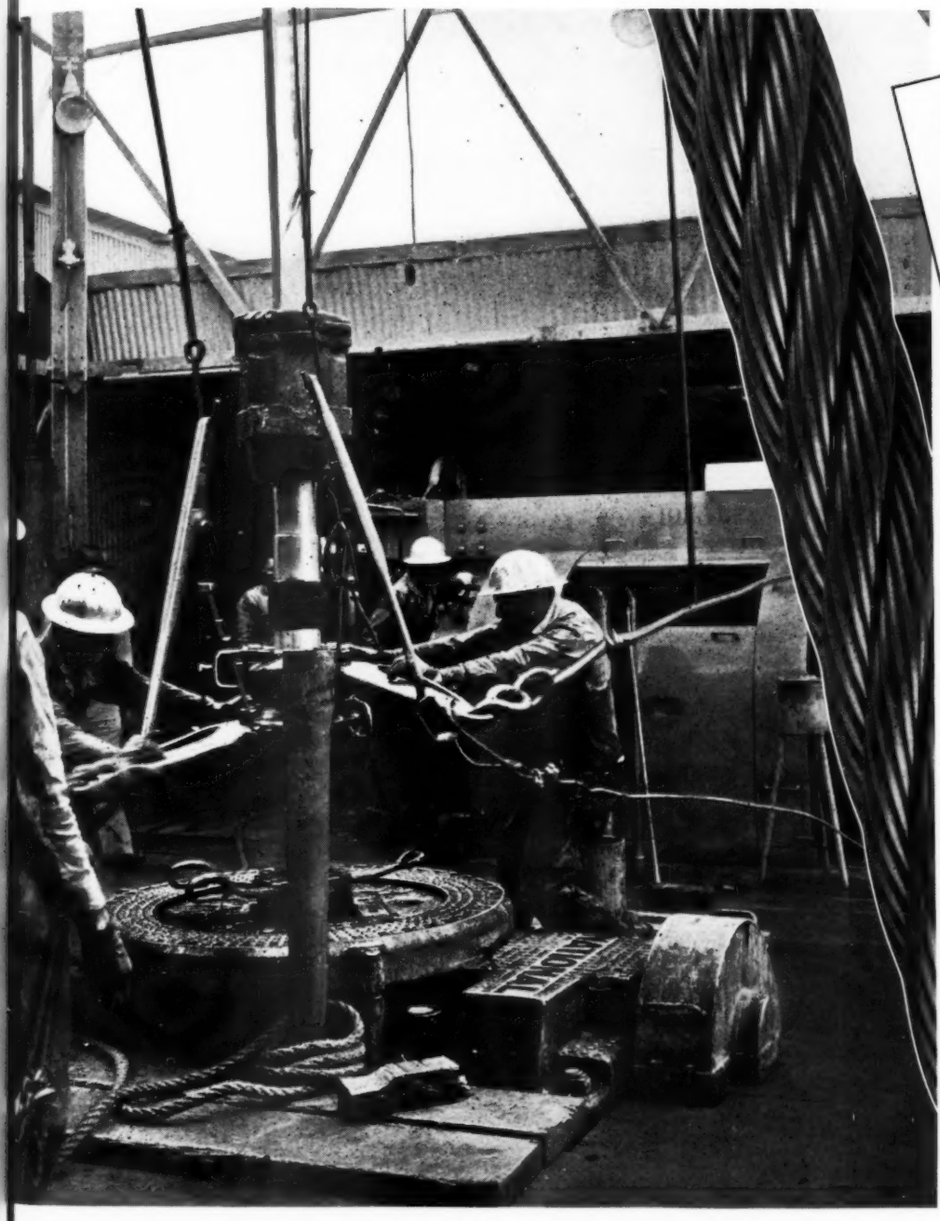
The gas is cooled after compression in atmospheric sections installed crosswise beneath a louver-type cooling tower and piped to a single low-pressure absorber using a Mid-Continent absorption oil. This stream of oil is split so that a small portion will flow to a tail absorber to contact vapors from the gasoline accumulator and storage tanks, to obviate the necessity of recompressing these vapors for salvage. Steam is used for pump power, and the water for cooling and for boiler use is produced from a shallow well on the premises that is reasonably soft and can be lifted in quantities sufficiently large for all requirements of the gasoline plant.

The main gathering lines are all of 16-in. welded pipe extending through the surrounding leases so that laterals can be connected to individual wells between the separators and back-pressure regulators on the vent lines. The header at the compressors is placed above the cylinders with control gates on short connections between the ports and the pipe flanges. The discharge from the compressors is beneath the floor and leads directly to the cooling sections north of the engine room. Prevailing winds are reported to be such that any spray from the tower will not damage the paint of any building.

Production from the 11,000,000 cu. ft. plant is about 20,000 gal. of 26/70 finished gasoline, but with equipment to fractionate the liquefied gases, the total production should be twice that amount. The normal production of the plant is processed in a stabilizing column equipped with an overhead shell-and-tube cooling unit to obtain the desired reflux to control the quality of gasoline removed from the reboiler at the base of the column. Loading is done at a switch on a railroad a few hundred yards south of the plant, so shipment may be had to any refineries requiring natural gasoline for blending.

Gas from the lime-producing horizons contains both H_2S and mercaptans, which are removed with a pre-caustic wash followed by a treatment with cupric chloride. The flow of gasoline is through the caustic wash and subsequent settling vessels, and to the copper sweetening plant, using the solid, or dry process in two vertical vessels that may be used in series or parallel, or singly when conditions warrant.

Doesn't this simplify your job?



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One of the best assurances of long, safe drilling line service is highly uniform quality. And that's something you can bank on to an exceptional degree when it comes to Roebling Drilling Lines. It helps to rid wire rope selection of worry and uncertainty . . . simplifies your job.

First of all, remember that great uniformity and dependability are "musts" in the Roebling business. When Roebling makes main cables and suspender ropes for the huge Golden Gate Bridge, for example, there can be no gambling! Secondly, unequalled testing facilities provide a double check on Roebling uniformity. And last—and most important—every manufacturing process from raw materials to final shipment is under complete Roebling control.

Ask the Roebling representative or your National Supply Salesman what this means out in the field. He will gladly give you convincing facts as to the actual service drillers are getting from either Roebling "Blue Center" Rotary Drilling Lines or Roebling Cable Tool Lines.

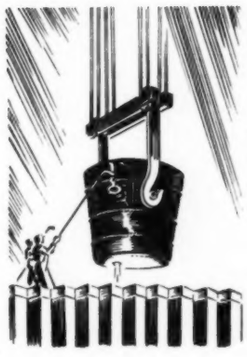
ROEBLING OIL FIELD LINES FOR EVERY PURPOSE

Roebling "Blue Center" Rotary Drilling and Casing Lines—Bailing and Coring Lines—Sucker Rod and Tubing Lines—Winch Lines—Spudding Lines—Sand Lines—Cable Tool Drilling Lines—Guy Strand—Dead Lines—Wire Rope Fittings.

CLOSE CONTROL OF WIRE ROPE QUALITY

When it comes to making wire rope of exceptionally great strength and stamina, such as Roebling Drilling Lines, ordinary production methods won't do. Painstaking care and skill of the highest order must be exercised.

Typical of this care is the close control of quality, in making Roebling "Blue Center" Rotary Drilling Lines—control from raw materials clear through to finished product.



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Bottom Water and Oil Production

Fallacy of the belief that bottom water must be pumped to recover the oil

By G. I. McBRIDE

Petroleum Engineer and Geologist, The Buttes Oilfields, Inc., Yuba City, California

THE writer believes that a theorem may be set up to govern the production characteristics of those wells in which the pressure is derived from bottom water, and that by application of this theorem more economical production and a doubled ultimate recovery may be obtained.

Prior to 1934 it had been the practice of valuation engineers to estimate the ultimate recovery of a property at between 40 and 60 percent of the calculable oil in place. The accuracy of the estimate depended largely on the extent of experience of the evaluator.

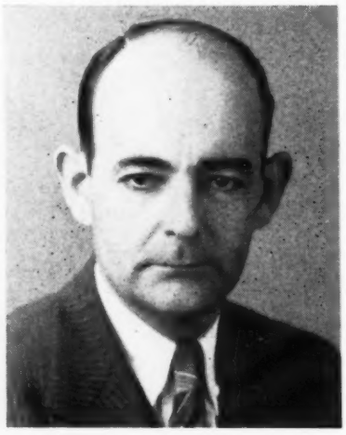
Newer production practices are bringing about a recovery that is indicated to be approximately 90 percent of the total oil in place, and such an improvement in a few areas suggests we do all possible to extend its benefits to other fields as well.

Argument: There are oil wells now pumping as much as 2000 bbl. of water daily that might just as well pump or flow pipe-line oil.

Not by chance is the East Texas field still flowing.

Not by chance has it already produced 3,000,000,000 bbl. of oil, thus doubling the best available 1934 figures on its *ultimate* recovery.

Not by any newly discovered laws of hydraulics has the oil-water interface been so closely controlled.



G. I. McBRIDE

received a B.S. degree in geology from the University of California, 1926—Upon graduation did geological work for Associated Oil Company, roughnecking and wellpulling for General Petroleum Corporation, was inspector for the California Mining Bureau, Division of Oil and Gas, then petroleum engineer for The Texas Company — The latter company transferred him to Louisiana in 1929, where he became chief engineer for Louisiana, Arkansas, and East Texas until the fall of 1936 — Followed a period of varied work in the Mid-Continent area—The last two years he has been engineer and geologist for The Buttes Oilfields, Inc.

No—a new concept of percentage recovery, and percentage profit, literally has been forced into our engineering treatises.

Reviewing the behavior of the East Texas field, one wonders why all fields, whether new or old, given comparable conditions of structure and permeability of its underlying water sand, may not be produced similarly.

Let us consider a specific East Texas well, whose records are in the Railroad Commission's office. The well is situated just north of the Henderson-Arp Highway in the central part of the field. Figs. 1, 2, and 3 clearly tell the story; enforced proration effected a lowering of the water level surrounding this particular well just as it effected a general leveling of the oil-water interface throughout the field.

From this one example, and there are many, let us postulate three propositions:

(1) It is possible to flatten a conical water table by reduced productivity.

(2) It is simpler for oil to travel along the bedding planes than for water to migrate upward across stratification.

(3) The limit of a well's economic productivity has been passed when *any* water is produced.

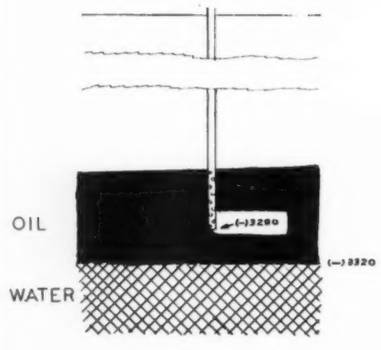


Fig. 1—1931

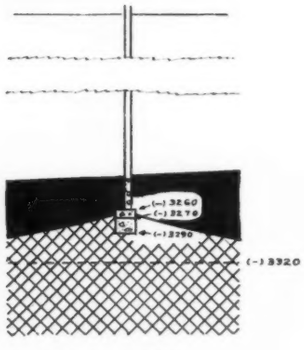


Fig. 2—1933

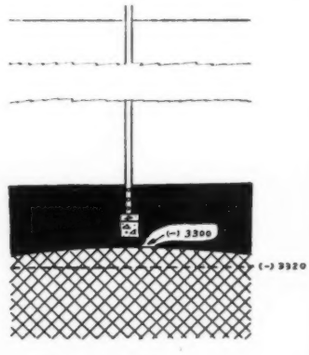
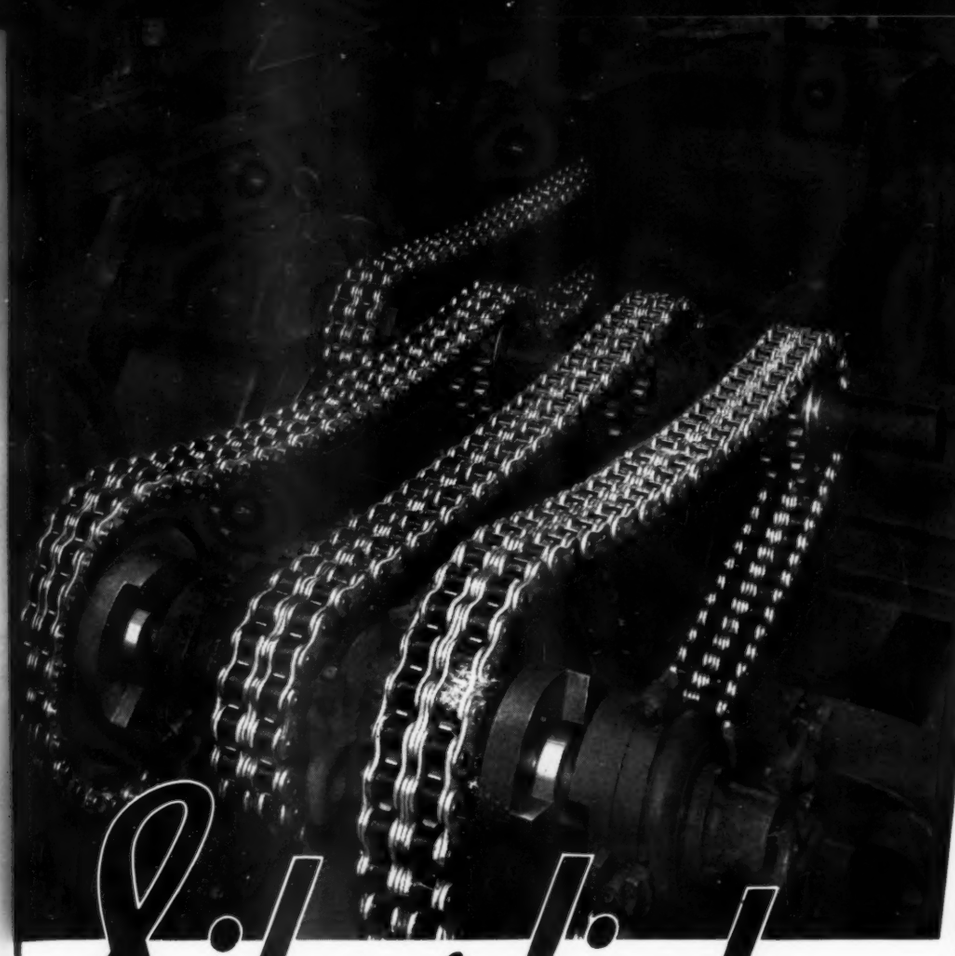
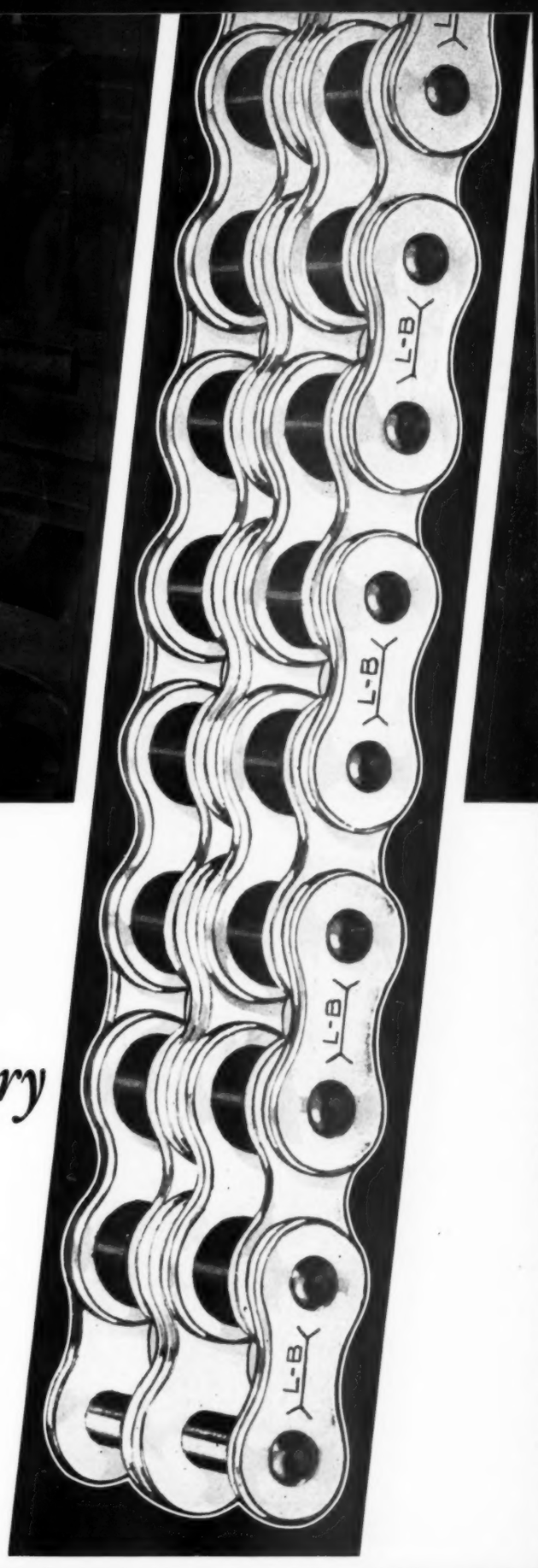


Fig. 3—1938

The above is the actual history of an early East Texas well. Plugged-back twice in 1933 to exclude bottom water, wells adjacent proved the area dry to —3300 ft. for at least 5 years following curtailment





Silverlink ROLLER CHAIN

The Choice of the Oil Country

● In this day of high speed drilling to extreme depths Link-Belt Silverlink has set the pace for dependable, long-life performance in the roller chain field. Rig Manufacturers and Operators alike recognize the value of Silverlink's accurately finished, all-steel construction, built to the highest standards of precision . . . that it combines great strength with comparatively light weight . . . that it is extremely flexible, assures smooth operation, and is especially capable of withstanding severe shocks . . . that it minimizes wear and repair. They recognize, too, the value of Link-Belt engineering service in working out problems in connection with the use of roller chains.

Silverlink Roller Chain is built in a complete range of sizes and types to meet practically every chain need . . . and is readily available from stocks carried by oil field supply houses.

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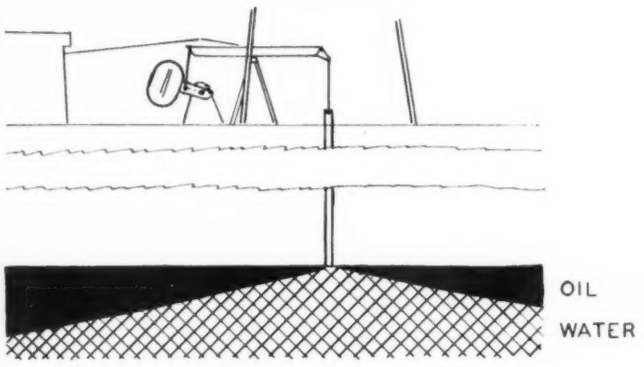
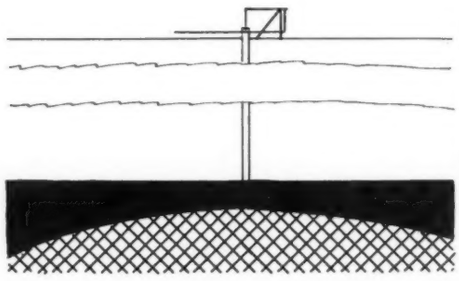
LINK-BELT *Silverlink* ROLLER CHAINS



Prior to 1934
40-hp. — 20 bbl. of oil — 750 bbl. of water

Fig. 4



Since 1934
4-hp. — 40 bbl. of oil — no water

Fig. 5

The reader will understand, of course, that the present discussion pertains only to fields or sands that are under easily migratory hydraulic control.

As an additional illustration the writer is reminded of a well in the Homer, Louisiana, oil field. Powered with a fully loaded 40-hp. engine, the limit of the rig was 20 to 23 bbl. of oil and 750 bbl. of water per day. For some three years its production curve showed no great deviation from this average. Upkeep was terrific; belt renewal, rod breakage, pump replacement, etc., suggested its abandonment. When the standard rig was moved away, however, an available jack was put over the hole with the result that 40 bbl. per day of pipe-line oil was pumped, using no more than 4 hp. (Note: As the jack could not lift the well's probable full potential, it would be the operator's normal desire to add horsepower and stroke until the original condition was duplicated; unable to pump more than 40 bbl. per day, the jack satisfactorily continued its pipe-line production.)

Figs. 4 and 5 illustrate what would seem to be the underground conditions necessary to explain the above performance.

Again, it is noteworthy that in the Long Beach, California, field the shallower zones produced earlier had all "gone to water," and were virtually abandoned in favor of the newer, deeper zones. A readjustment of the oil-water interface then occurred, making it profitable, during the last two years, to drill several wells and thus again obtain commercial production from these shallow formations.

What, after all, is "water-flooding" but the controlled operation of a water drive to flush out those sands so unfortunate as not to have a natural hydrostatic drive? And in water-flooding, does the operator bend every effort to pump out the water as fast as he can pump it in?

There persists an idea in the minds of many producers that to obtain the most oil one must pump the most water. For example, in the Gulf Coast there was a well flowing 100 bbl. oil and 100 bbl. water. Cleaning or swabbing failed to increase its rather low rate of flow, until finally a drilling rig was moved in to deepen the hole 100 ft., with the thought that the increased water production would stimulate the oil recovery. Additional water was obtained, but there was no increase in oil.

In the Smackover field there had been a number of old 25- to 40-hp. rigs, producing all the water the equipment was capable of handling. These were torn out and replaced with heavier equipment, at $8000 per changeover, without economic success.

In the Seminole area the writer had an interesting discussion with the chief engineer of a major company who told this perplexing story: Plans were under way to handle the heavy, watered production by (1) installing 4-in. tubing, 1½-in. hollow sucker rods, and 100-hp. prime movers, while (2) *simultaneously*, the operations were to be so modified that these wells could be placed on a central power, and no water produced. Such divergence suggests that one department may have had in mind a plan perhaps similar to this discussion. The writer is not aware of the outcome.

There are more wells and areas that could be mentioned for illustrative purpose, but it is believed that the foregoing is sufficient.

There is nothing shown in Figs. 6 and 7 that is not universally known, yet it seems wise to discuss them. Let Fig. 6 describe a hypothetical condition in which some 40 bbl. of oil and 400 bbl. of water are pumped. Working fluid level stands at (a); working bottom-hole pressure at the face of the sand is, say, 10 units of pressure; bottom-hole pressure between wells is, say, 40 units. It is obvious the working fluid level must be maintained at (a) to maintain production of 40 bbl. of oil.

On the occasion of the first rod break, the greater pressure and volume of water compresses the free and expanded gas existing outward from the bore of the hole, and approaches the condition shown in Fig. 7, where (b) is the static fluid level. This indicates the amount of water that must be pumped-off before the well is brought back to "normal," and helps to explain the field preference for heavy equipment, to get the well back on sooner, and to keep the working fluid level as low as possible, even though the gain is only an illusory one.

It is believed to have been at least indicated that a producing condition such as shown in Fig. 5 may be obtained for wells operating under hydraulic control. In this sketch it will be noted that the upward spherical water surface has not broken through and up the tubing.

Question: What must be the production rate to obtain this optimum condition? Fig. 5 indicates 40 bbl. per day. This is a random guess, however, and not necessarily maximum. The East Texas field as a whole indicates

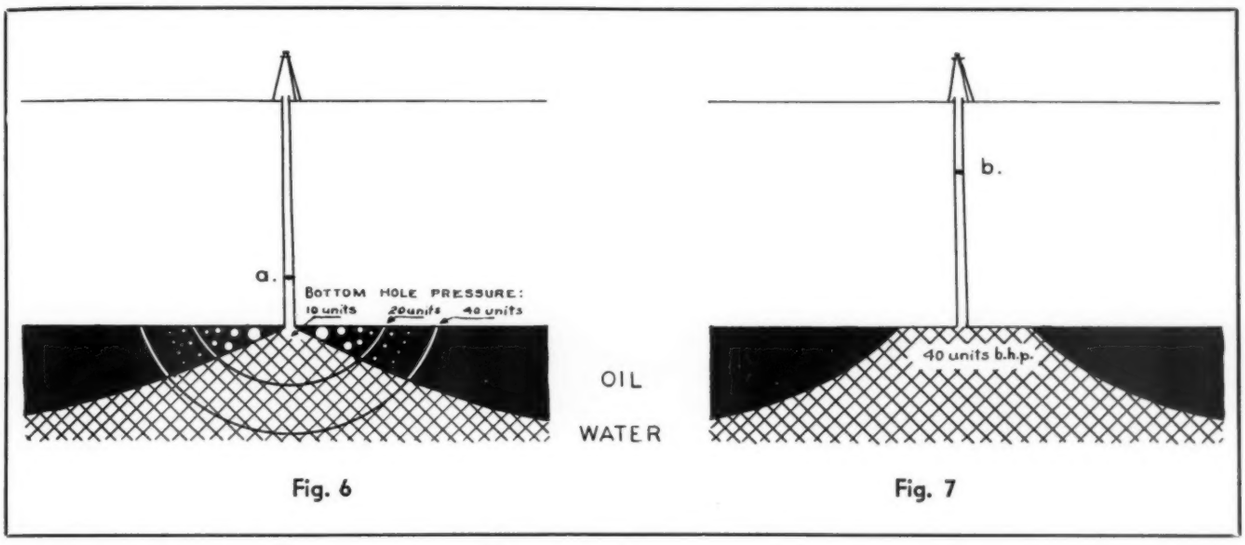


Fig. 6

Fig. 7

20 bbl. per day, but with all gas in this field present in the liquid phase, and with its abnormally low gas-oil ratio, this field is one of the poorest for the optimum rate. We will concede conditions of limited depth and low permeabilities that may limit the "economic maximum" to 1 bbl. per day. But we argue that on the average, rates of from 25 to 100 bbl. per day should be obtained, and with them a doubled ultimate recovery, and a per-barrel recovery at less than one-half the watery lifting cost.

Viewing this latter consideration from an economic angle, which method would be the more desirable? Assuming the economic life of a presently heavy pumping well at 5 years, and that in its average production of 50 bbl. of oil and 500 bbl. of water the lifting costs are $0.60 per bbl. of oil, this well will net $36,500 on the basis of oil at $1.00 per bbl. Now, pumping less than 50 bbl. of oil and no water, daily, the lifting costs should not be more than $0.20 so, together with at least doubling the future recovery, the well should net, say, $146,000, though over a longer period of time.

In view of the enforced benefits resulting from East Texas practice the writer does not consider the above other than a quite probable gauge of the possibilities.

The writer has not had any practical experience in "skimming." Proper skimming would have the same beneficial results indicated in this paper. In discussing this production method, however, one gathers that the operators hoped to skim more oil than they could pump deep. Further, it is questionable whether those skimming methods were conducted under supervision as rigid as that which accompanied East Texas production.

Conclusions: If we define "maximum economic productivity" as the utmost rate at which wells may produce without showing *any* water, then:

(1) The writer has knowledge of its adaptability to certain areas.

(2) Reasonably it could be broadened to include other areas.

(3) It is applicable to old as well as new fields.

(4) The "wetter" the property, the better.

(5) It presents enormous economies in surface equipment capacity and maintenance.

(6) It eliminates sand trouble.

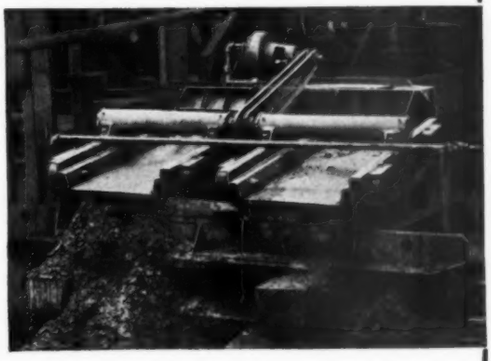
(7) It eliminates salt water electrolysis and corrosion trouble.

(8) It eliminates necessity for salt-water disposal.

Water in this article refers to bottom water—the producer doesn't want it—why pump it?

WORLD'S CHOICE METHOD of RECONDITIONING ROTARY DRILLING MUD

• The Link-Belt mud screen dual hook-up, pictured here in the field and used also as a single unit, is accepted worldwide as the latest and most efficient method of economically reconditioning rotary drilling mud. With its many new and exclusive features this advanced design is a result of Link-Belt's constant research and improvement since introducing the oil field's first vibrating screen more than 10 years ago.



The dual hook-up employs two 24" x 48" screens mounted on skids as one unit, with one mud collecting tank and inlet chute. A single turbine (or motor) drives both screens . . . handling the fluid of today's largest pumps . . . yet the screens operate independently when only one is required. Write for detailed literature, just off the press.

LINK-BELT COMPANY Philadelphia, Houston, Dallas, Los Angeles, Indianapolis, Chicago, New York. Sold by most supply houses. 8184A

LINK-BELT MUD SCREEN

Running Tour
WITH MEN IN THE INDUSTRY

COLONEL HARRY T. KLEIN has been named executive vice-president of The Texas Company, according to an announcement by **W. S. S. RODGERS,** president. He also will be general counsel, which office he has held since 1925. Klein has been a vice-president of the company since 1933. **C. E. OLMSTED,** vice-president in charge of refining, has been placed in charge of the export department, and **MICHAEL HALPERN,** general manager of refining, has been elected vice-president to assume Olmsted's position.

J. A. MUSSLER, manager of tubular sales, Continental Supply Company, Dallas, and **J. W. OWINGS,** field engineer of the Tubular Division, Youngstown Sheet and Tube Company, Youngstown, Ohio, recently made a three weeks' trip through the Mid-Continent area, where they showed motion pictures in color of the seamless process of manufacturing casing, line pipe, tubing, and drill pipe.

GEORGE E. MASON, of the sales department of W-K-M Company, Inc., Houston, Texas, and commissioned as a Captain in Ordnance Department Reserve, was ordered to report for active duty at St. Louis, Missouri, according to U. S. Army Orders from Washington. Captain Mason has been with W-K-M Company for several years, recently working the South Texas district out of Corpus Christi, Texas.

JOHN P. KLEP, Houston, Texas, representative of the Sperry-Sun Well Surveying Company, gave a most interesting talk before the Petroleum Engineering Club of Texas A. & M., October 18. His subject was "Well Surveying Methods and Their Application.'" Klep stressed the reasons for surveying wells and the types of instruments developed to help the driller keep the hole straight. Klep was accompanied by **MR. HYER,** district manager of Sperry-Sun Well Surveying Company.

ALEX McCUTCHINS, independent operator, has moved his headquarters from Tyler to Dallas, Texas.

WALTER W. WILLIAMSON recently joined the industrial V-belt division of The Dayton Rubber Manufacturing Company, Dayton, Ohio, in the capacity of sales representative in the Mid-Continent oil fields, with headquarters at 519 Santa Fe Building, Dallas, Texas. Williamson has had extensive experience in the sales of power transmission equipment and is especially well known to oil field and industrial accounts in the Midwest territory. Since 1914, he has been connected in various capacities with manufacturers serving both the oil field trade and industrial plants.

C. L. McMULLEN has joined the staff of the Buda Company of Harvey, Illinois, (Chicago suburb) in an executive sales capacity, it has been announced by **R. K. MANGAN,** executive vice-president of the Buda Company. McMullen goes to Harvey from Madison, Wisconsin, where he was vice-president of the Gisholt Machine Company. Before that, he was associated with the Caterpillar Tractor Company at Peoria, Illinois.

BEN BAYLESS, mechanical engineer, Shell Oil Company, Inc., is now making his headquarters at Tulsa, Oklahoma, having been transferred from Pampa, Texas.

RICHARD P. DODDS, advertising and sales promotion manager of the Truscon Steel Company, Youngstown, Ohio, was elected president of the National Industrial Advertisers Association at its recent Annual Conference, held in Detroit. Vice-presidents elected were: **E. J. GOES,** Koehring Company, Milwaukee; **HERBERT V. MERCREADY,** Magnus Chemical Company, Garwood, New Jersey; **TERRY MITCHELL,** Frick Company, Waynesboro, Pennsylvania; **W. D. MURPHY,** Sloan Valve Company, Chicago; **LOUIS J. OTT,** Ohio Brass Company, Mansfield, Ohio; **R. T. REINHARDT,** California Corrugated Culvert Company, Berkeley, California. **E. C. HOWELL,** of the Carboloy Company, Detroit, was elected secretary-treasurer. **MILDRED R. WEBSTER** is national headquarters secretary in Chicago.

MEL B. TRELFALL, Houston, Texas, has been appointed sales representative for Clayton-Mark and Company, manufacturers of handle-bar unions and check unions. Trelfall is well known in the oil country. After serving as a first lieutenant aviator in the Marine Corps during the World War, he entered the oil industry, having worked for several supply companies and gaining a varied experience. He will cover the Mid-Continent, Gulf Coast, and Rocky Mountain areas, working through Continental Supply Company stores.

MORRISON MILLS, eastern district manager of the Construction Equipment Division of Chain Belt Company of Milwaukee, Wisconsin, died recently in Philadelphia, Pennsylvania, where he made his home. Mills was service manager of the Construction Equipment Division of the company from 1931 to 1937, and eastern district manager since that time.

I. W. HUGHES, formerly assistant division superintendent at Smackover, Arkansas, for the Phillips Petroleum Company, has been promoted to assistant to **AUSTIN ALLEN,** chief petroleum engineer, and transferred to Bartlesville, Oklahoma.

D. V. CARTER, chief production engineer of the Magnolia Petroleum Company, Dallas, Texas, left for South America late in October to make a tour of the principal holdings in Venezuela and Colombia of the Socony Vacuum Oil Company, the parent organization. He expected to be gone about five weeks.

CARL B. KING, president of the Carl B. King Drilling Company, Dallas, Texas, is recovering nicely in a Durant, Oklahoma, hospital from injuries suffered in a car accident on October 16 that necessitated the amputation of his left leg.

JAMES CLARK has been made manager of Standard Oil Company of Venezuela's operations at Caripito. He has been manager for Lago Petroleum Company at Maracaibo.

New!

The new "Oilwell" 21-inch Super-Speed Rotary really makes straight hole in a hurry. It is built for 1000 r.p.m. operation, and is remarkably free from vibration. Extensive testing at this high speed assures efficient, trouble-free service under the most severe conditions.

Outstanding Features:

★ **Fully heat-treated, forged alloy-steel, spiral-bevel gear train with surface-hardened pinion.**

★ **Self-centering, angle-contact main bearing with large-diameter, precision, steel balls and surface-hardened, heat-treated and ground, alloy-steel races.**

★ **Forced-feed lubrication system assures positive lubrication at all speeds, and keeps the hold-down ring bushing under constant pressure. Splash lubrication is also provided, and the large-capacity oilbath is sealed to exclude mud and water and to prevent the loss of oil.**

★ **The fully heat-treated pinion shaft, pinion, locking-wheel, lubricator drive pinion, shaft roller bearings and housings comprise a compact and sturdy unit-assembly, which fits into a cylindrical opening cast integrally with the base, providing a very rigid construction.**

★ **Safety tread on the top of the one-piece, cast-steel base and on the top and sloping sides of the table guard.**

★ **Locking arrangements are safe, convenient and semi-automatic in operation.**

Dead-load Capacity	300 tons
Recommended Drilling Depth	17,000 feet
Maximum Recommended Speed	1000 r.p.m.
Gear Ratio	2.61 : 1

This ratio permits real high-speed rotation with efficient engine speeds. This rotary is adaptable to "Oilwell" Rotary Drilling Units—the safe and economical drive for high-speed drilling.

Buy an "Oilwell' Super-Speed Rotary *today* and be prepared for *tomorrow*.

OIL WELL SUPPLY COMPANY

DR. CHARLES E. LANNING, of the foreign refining department of the Standard Oil Company of New Jersey, and **C. A. NATRION,** of the Colombian Petroleum Company, sailed from New York City for South America recently.

RAYMOND F. HADLEY, electrical engineer for the Susquehanna Pipe Line Company, Philadelphia, Pennsylvania, recently received the Beal Medal from the American Gas Association, which is awarded for the best paper presented at a meeting of the association during the year. The paper for which the award was made was entitled "Studies in Microbiological Anäerobic Corrosion."

H. F. MILLER, general sales manager of Goulds Pumps, Inc., Seneca Falls, New York, recently made a business trip through the Mid-Continent and Texas oil fields.

PAUL STEIN, consulting petroleum engineer of Vienna, died on August 27, 1940, according to word just received in the United States.

CAPTAIN V. McNEIL COOKE, Second Batallion of the Royal Scot Fusiliers, has been awarded the British Military Cross for gallantry in action. Before the war he was on the London North staff of the Vacuum Oil Company, Ltd.

CHARLTON H. LYONS, independent operator of Shreveport, Louisiana, has been named president of the Louisiana-Arkansas Division of the Mid-Continent Oil and Gas Association, replacing **L. MOSELEY MOFFITT,** also of Shreveport.

TOM PRETTYMAN, geologist and independent operator of Fort Worth, Texas, died unexpectedly on November 2.

I. FRANK BROWN, New York City, export representative, is making a six weeks' trip to Trinidad, Venezuela, and Colombia.

DEAN C. GLASS, engineer, The Pure Oil Company, has been transferred from Van, Texas, to Columbus, Ohio.

DR. GUSTAV EGLOFF, director of research of the Universal Oil Products Company, Chicago, Illinois, has been awarded the Octave Chanute Medal for 1939-40 by the Western Society of Engineers. The award was for his paper "Motor Fuels of the Present and Future," delivered before the society in December, 1939.

GEORGE W. CURTIS has been appointed Milwaukee division manager of The Timken Roller Bearing Company. Industrial and automotive bearing sales as well as alloy-steel sales activities of this division will be under his supervision. Since Curtis' graduation in 1920 from Carnegie Institute of Technology he has served in important engineering and sales capacities at Canton, Ohio, and Pittsburgh, Pennsylvania. Upon his transfer from Pittsburgh to Milwaukee in 1930 he was made district manager of the industrial division.

GORDON M. MICHLER, of the Standard Oil Company of New Jersey, and **HAROLD D. HUMPSTONE,** president of the West India Oil Company, have returned to the United States after a recent trip to Chile, South America.

EARLE H. BURGESS, sales manager of Penberthy Injector Company, has recently visited the Mid-Continent and Texas oil country.

W. I. FOX, production engineer for the Illinois Division of The Texas Company, has been transferred from Salem to Tulsa, Oklahoma. **STEWART KENT,** assistant engineer, succeeds him in Illinois.

E. C. BREENE, JR., petroleum engineer, International Petroleum Company, having his headquarters in Peru, is in Oil City, Pennsylvania, on a furlough after spending three years in South America.

CHARLES T. CONRAD, engineer with Gulf Oil Corporation, has been transferred from Tulsa, Oklahoma, to Cotton Valley, Louisiana.

M. H. BUSH, drilling superintendent for Bahrein Petroleum Company, has returned to his headquarters in the Bahrein Islands after making a tour of United States oil fields.

RALPH CHAMBERLIN, in charge of the Mid-Continent territory for Ridge Tool Company, has transferred his headquarters from Tulsa, Oklahoma, to Houston, Texas. Chamberlin enjoys an extensive friendship not only in the Mid-Continent area but throughout the oil industry.

GLEN E. COX, Shelby, Montana, recently was made superintendent in the Kelvin field, Montana, by Superior Petroleum Company. He succeeds **GEORGE R. DOWNS,** who resigned to go with Carter Oil Company as a geologist.

DR. MARTIN W. BADEN has been named chief geologist of the Marland Oil Company, which recently moved its headquarters from Ponca City, Oklahoma, to Arkansas City, Kansas.

HENRY LINAM, president of the Standard Oil Company of Venezuela, and **CHESTER CREBBS,** president of the Mene Grande Oil Company, arrived in the United States recently.

JOHN SCHULTZ, drilling and production superintendent for Mammoth Producing and Refining Corporation, Clare, Michigan, has resigned to affiliate himself with the Cryden Petroleum Corporation, Mount Pleasant, Michigan. He will be in charge of drilling and producing operations for his new company.

A. S. DONNELLY, geologist for the Honolulu Oil Corporation in West Texas, has been appointed secretary-treasurer of the North Basin Pools Engineering Committee. He succeeds **R. R. PORTERFIELD** of the Devonian Oil Company, Midland, who resigned recently.

E. W. KRAMPERT, Casper, has been appointed Wyoming State Geologist to succeed **DR. S. H. KNIGHT,** resigned. Krampert has served Roxana Petroleum Company, Prairie Oil and Gas Company, and Superior Petroleum Company. In recent years he has practiced as a consultant.

WILLIAM V. VIETTI, who has been manager of The Texas Petroleum Company, at Bogota, Colombia, has been made vice-president and manager of Colombian Petroleum Company, subsidiary of The Texas Company, which operates the Barco concession. **J. O. BOWER** succeeds Vietti as manager of The Texas Petroleum Company.

HAROLD S. KELLY, assistant chief engineer, Phillips Petroleum Company, Bartlesville, Oklahoma, has been made assistant division superintendent for West Texas, Texas Panhandle, and New Mexico. His headquarters are at Amarillo, Texas.

WAYNE I. MILLER, engineer with Phillips Petroleum Company, has been moved to Bartlesville, Oklahoma, headquarters from Borger, Texas.

H. F. SMITH, superintendent for the Magnolia Pipe Line Company in North Texas, has moved the headquarters of himself and staff from Electra to Wichita Falls.

STOP THAT "CHARGE"...

PROFIT! BY USING Utility ELECTRIC POWER

USE Utility Electric Power!

★ "Stop that Charge" means just as much in the oil field as it does on the football field. More so, in fact, for men in the oil industry must wage incessant warfare against the ever-mounting costs of oil production. Small wonder, then, that oil men in ever-increasing numbers are putting Utility Electric Power in operation wherever and whenever costly power charges appear.

These men have learned to their great satisfaction that Utility Electric Power rapidly and efficiently stops unnecessary charges such as: Fixed charges, downtime, etc. These men know their cost sheet will prove conclusively that Utility Electric Power keeps operating expense at a minimum. Low in first cost, economical in maintenance, and greater salvage value. Your nearest electric power service company will gladly give you facts and figures concerning your power needs. Call or write them today!

PETROLEUM ELECTRIC POWER ASSOCIATION

LAUGH WITH BARNEY

Silas: Boy, oh boy, did Tillie throw a party last night!

Jake: You don't say. Who all was there?

Silas: Just me and Tillie.

The rejected suitor rose with dignity to his full height.

He: Then this is absolutely final?

She (calmly): Quite; shall I return your letters?

He: Yes, please. There's some very good material in them that I can use again.

Man Motorist (barely avoiding broadside crash): Why on earth didn't you signal?

Girl (who had crossed into her home driveway): I always turn here, stupid.

Not Contagious!

Annie: Why don't you come in and see our new baby, teacher?

Teacher: Thank you, but I will wait until your mother is better.

Annie: You needn't be afraid. It's not catching, teacher—honest.

"I want to buy a cake of soap," said Mrs. O'Brien to the grocer.

"What kind?"

"I don't remember the name," replied Mrs. O'Brien. "But it's the one the advertisements speak of so highly."

Diner: Look here, waitress! There isn't a particle of turtle in this turtle soup.

Waitress: Well, what of it? We have cabinet pudding, but you wouldn't expect to find Harold Ickes in it, would you?

Collector: Is your husband home?

Blonde: Why?

Collector: I want to collect the installment on that sofa.

Blonde: Sh!! Not so loud. He'll be gone in a minute.

Him: We certainly had a big time last night for 10 cents.

His Gal: I'll say! I wonder how little brother spent it.

Grandpaw was at his first dance. His granddaughter asked, "I'll bet you never saw anything like this in the gay nineties, did you, Grandpaw?"

"Once," said Grandpaw, "But that was on my honeymoon."

Marriage, Arkansas Abe says, is like boxing. Preliminaries often are better than the main event.

Dzudi: What's the difference between a modern and an old-fashioned kiss?

Sally: Oh, about five minutes.

The president of a New York bank called in the office manager one day, and said, "I want a new stenographer. Miss S— is a good one, but she's so infernally attractive everybody stops to visit with her. Get me a plain one."

The next morning when the president buzzed for his stenographer, there came in a very plain-looking woman, about sixty-five years old, with a sallow complexion, a dour visage, and a watery blue eye. The president gave her the dictation, excused her, then again called for the office manager.

"I know," said the president, "that I asked for a plain stenographer, but why be sarcastic about it?"

"Winter draws on," remarked John as he tucked Leona into his cutter for an old-fashioned sleigh ride.

"Is that any of your business?" replied Leona icily.

The hotel seemed very stuffy to the traveling man. In vain he tried to sleep. Before getting into bed he had endeavored to open the windows but found them all sealed. He tossed and turned until, at last, in desperation he got out of bed, wrapped a towel round his hand and smashed a window. Then he breathed deeply, got back into bed and fell into a deep and refreshing sleep.

Next morning he had to pay $2.00 for smashing the mirror above the bureau.—*Kreolite News.*

Jones picked up a clever talking parrot in a bird shop and had it sent home. The same day his wife went out and ordered a chicken. She told the cook to roast the bird for dinner that night, and the cook thought she meant the parrot.

When Jones found out, he exploded with rage.

"That parrot could speak nine languages!" he told the cook.

And the cook said, simply:

"Then why on earth didn't it say something?"

The club's worst member—a banker of note—was addressing his golf ball. He waggled his driver to and fro for several minutes, missed four swings, and finally managed to hit the ball about a dozen feet. Then he glanced up and saw a farmer who was walking across the field and who stopped to watch him.

"I say," he protested, "only golfers are allowed on this course, you know."

The farmer knodded. "I do know," he replied, "but I won't say nothin' if you don't.

Breathes there a man with soul so dead, who never hath turned his head and said, "Hmmm, not bad!"

Sliding Scale

An optician was teaching business technique to his son.

"Son," he said, "after you have fitted glasses to a customer, and he asks what the charge is, you say:

" 'The charge is ten dollars.'

"Then you watch close to see if he jumps a little. If he doesn't jump, you say:

" 'That's for the frames; the lenses will cost another ten dollars.'

"Then you stop again, for just a second, to see if he jumps. If he doesn't jump that time, you say—real quick—

" 'Each.' "

A group of big oil men in Washington were talking one evening about government taxation.

"There is no telling where we will land by the time the tax bill is settled," said one. "Our status is as uncertain as that of an old Negro slave I once heard of. Somebody asked him who he belonged to. 'I don't know, suh,' he replied. 'Old Marse, he's upstairs playin' pokah.' "

Greatly agitated, a woman carrying an infant dashed into a drug store.

"My baby has swallowed a bullet!" she cried. "What shall I do?"

"Give him the contents of this bottle of castor oil," replied the druggist calmly, "And then be sure you don't point him at anyone!"

Father: I want you to stop running around with that wild woman.

Son: She isn't wild, dad. Anybody can pet her.

"For Friendly Service, and Dependable Products, Specify BAKER"

BAKER CEMENT RETAINER — SAVE A WELL

BAKER

CEMENT RETAINER

CASE STUDY NO. 407

PROBLEM: *To shut off wet zone behind slotted casing*

METHOD: *Bridge slotted interval with Baker Cement Retainer (as a Bridge Plug) and perform multiple-batch squeeze cement job with second Retainer equipped with 40' (drillable) tail pipe*

RESULT: *Complete water shut-off obtained*

• DETAILS •

Field: Maricopa, Calif.

Depth of Well: Approx. 3500'

Depth Retainer Set: 2475'

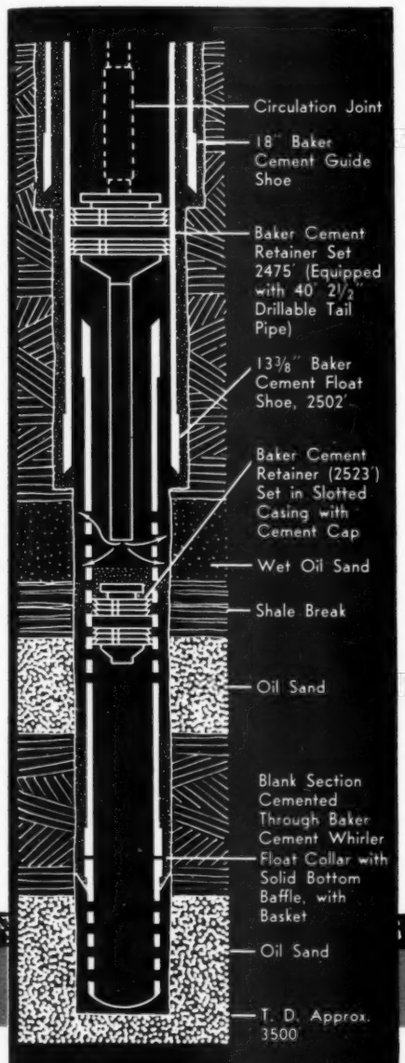
Breakdown Pressure: 100 #

Final Pressure: 1st. batch - 100 Sax - 800 #

Final Pressure: 2nd. batch - 100 Sax - 1500 #

Number of Sax Put Away: 200

How Cement Discharged: Through lower end of Tail Pipe into 20' section Slotted Casing


Circulation Joint
18" Baker Cement Guide Shoe
Baker Cement Retainer Set 2475' (Equipped with 40' 2½" Drillable Tail Pipe)
13⅜" Baker Cement Float Shoe, 2502'
Baker Cement Retainer (2523') Set in Slotted Casing with Cement Cap
Wet Oil Sand
Shale Break
Oil Sand
Blank Section Cemented Through Baker Cement Whirler
Float Collar with Solid Bottom Baffle, with Basket
Oil Sand
T. D. Approx. 3500'

Use of Baker Cement Retainers to Blank Off Wet Oil Sand Behind Slotted Casing

7

A Case Study of an Actual Well Repair Problem Solved By Using the Baker Cement Retainer.

THE BAKER CEMENT RETAINER has provided the solution to many Cementing, Well Repair and Well Completion problems confronting the modern operator . . . perhaps it will solve a particular problem confronting YOU. Complete details concerning its many practical field applications will be found in the Baker section of the Composite Catalog . . . also in Baker Broadcast No. 17-A, a comprehensive, 40-page illustrated treatise which will be sent to interested oil men upon request.

BAKER OIL TOOLS, INC.

Main Office and Factory, 6000 S. Boyle Avenue
P. O. Box 127, Vernon Station, Los Angeles, California

Central Division Office and Factory:
6023 Navigation Boulevard, P. O. Box 3048
Houston, Texas

Export Sales Office:
19 Rector Street
New York, N. Y.

IMPORTANT CEMENT RETAINER APPLICATIONS INCLUDE:
Squeeze Jobs • Recementing • Cementing Behind Sections of Pipe • Reducing Gas/Oil Ratios • Series Cementing • Plugging off Bottom Fluids • Plugging Back to Upper Zones • Testing Upper Cased Formations • As a Heaving Plug • As a Bridge Plug at any Place in Casing or Liner • Open Hole Acidizing • Open Hole Squeeze Cementing

BAKER CEMENT RETAINER

MACHINERY and EQUIPMENT

Globe Forged Blade Drag Bits

J. H. Howard, vice-president of Globe Oil Tools Company, Los Nietos, California, announces a new line of Globe Forged Blade Drag Bits in a complete range of sizes, and in 2-blade, 3-blade, and 4-blade types.

Two-blade type drag bit with one circulation hole per blade

According to the manufacturer, the blades of these new bits are drop forgings of a selected alloy steel, heavily set with borium and faced with tube borium. The bit body is special alloy steel that is very adaptable to welding, and is heat-treated for exceptional durability. All heat-treating is done in the Globe plant under the supervision of the metallurgical department, and every blade is given an individual brinell test.

Of the many features asserted by the manufacturer, particular emphasis is placed on the relative ease with which worn blades are replaced and the bit bodies used for subsequent runs. This is of special interest to foreign operators.

Operators interested in obtaining further information should address the manufacturer direct, requesting Bulletin No. 25.

"Oilwell" 21-in. Super-Speed Rotary

THE recent trend to ever-increasing rotating speeds has created a need for equipment specifically designed for this service. To meet this demand Oil Well Supply Company, Dallas, Texas, has developed its new 21-in. Super-Speed Rotary, designed for and tested at speeds as high as 1000 r.p.m. Recommended maximum drilling depth is 17,000 ft.; rated supportable dead-load capacity is 300 tons, and gear ratio is 2.61:1.

Its construction embodies many advanced features. The gear train is of the quiet-operating spiral-bevel type. Both gear and pinion are fully heat-treated, forged, alloy steel, and in addition the pinion is surface-hardened. The main bearing, specially developed for high-speed applications, is of the self-centering, angle-contact ball type with surface-hardened, heat-treated and ground, alloy-steel races and precision-ground steel balls of large diameter.

Positive forced-feed lubrication is a very important feature of this high-speed machine. A pump circulates a steady flow of oil through each of the pinionshaft roller-bearing assemblies and through the hold-down ring, keeping the latter under positive pressure. It also sprays oil into the spiral-bevel pinion, and the meshing of the gear teeth forces a stream of oil into the main table bearing. In addition to the forced-feed lubrication, the pinion picks up oil from the oilbath and the resulting splash causes it to flow through separate troughs to each of the pinionshaft roller bearings; thus conventional splash lubrication is provided in addition to the positive forced-feed system. A pressure relief valve and a pressure gauge are included in the forced-feed system. The gauge is inset in the side of the base where it is visible and is protected against damage by an open mesh screen.

Oil for both lubrication systems is picked up from a large reservoir in the base after it passes over an overflow wall from a large settling basin in which the oil is not churned up and where foreign matter settles into pockets at the cleanout drains. This assures clean oil for all parts subject to wear. The table hold-down rings overlaps the oil-retainer ring, providing complete return of the lubricant at all times.

A labyrinth seal at the circumference of the table prevents the loss of oil at the top of the base and keeps mud and water from entering the oilbath. This seal is covered by a strong cast-steel table guard, which is bolted to the base and is completely surfaced with a diamond-pattern safety tread. In addition to providing for the protection of the crew, this guard prevents mud from being slung over the derrick floor. It is flared outward to dispose of mud without allowing it to cake around the labyrinth seal.

The fully heat-treated pinionshaft, pinion locking wheel, lubricator drive pinion, shaft roller bearings, and their housings comprise a compact and extremely sturdy unit-assembly that fits into a cylindrical opening cast integral with the base, providing a very rigid construction. Locking arrangements are safe, convenient, and semi-automatic in operation.

A MIGHTY USEFUL BOLT DIE STOCK

Quick, easy, positive adjustment for oversize or undersize threads. Turn the knurled ring to large or small. Adjustment assures all four cutting edges cutting equal and therefore easier cutting and longer die life. Segmented dies are easy to resharpen or can be replaced at small cost.

Two models. No. 101 capacity ¼" to ⅝". No. 102 capacity ½" to 1". Either National Coarse or National Fine threads. Any combination furnished. Order from your local dealer in combination desired.

THE TOLEDO PIPE THREADING MACHINE CO. TOLEDO, OHIO

NEW YORK OFFICE, 502 No. 2 RECTOR STREET BLDG.

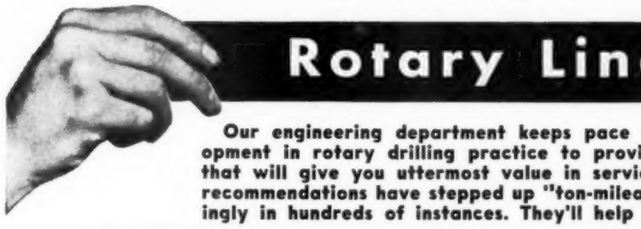
"TOLEDO"

Yellow Strand

One strand of yellow in your rotary line marks it unmistakably as being made of the finest steel wire in the world, drawn to our own specifications—marks it as the highest product of a company that has devoted 64 years solely to wire rope making.

"Flex-Set" Preformed

When you ask for "FLEX-SET" PREFORMED Yellow Strand, you get something BEYOND the elasticity, toughness and strength of standard Yellow Strand—a line so limber that it's installed in less than no time and gets off to a quick start because it's practically pre-broken in—a line that's easily spliced, resists kinking, fatigue, whipping, and wickering.



Rotary Lines

Our engineering department keeps pace with every development in rotary drilling practice to provide you with lines that will give you uttermost value in service. Our engineers' recommendations have stepped up "ton-mileage" records amazingly in hundreds of instances. They'll help you, TOO.

BRODERICK & BASCOM ROPE COMPANY

Houston Branch: 1311 Palmer Street, Houston, Texas

THE CONTINENTAL SUPPLY COMPANY

Mid-Continent and Rocky Mountain Distributors

Y-12

FREE Drillers' Hand Book

Engineering data and helpful guidance for drillers and purchasing agents. Write for free copy.

Here's a CEMENT PLUG *Problem!*

When gas can work through a freshly placed cement plug, the physical properties of the plug will be destroyed.

—and here's what to do about it—

Hold the gas back by dumping a heavy mixture of ⅓ sand and ⅔ cement.

←with the CAVINS CEMENT DUMP BOTTOM

You can do it easily—the discharge end of this tool is full opening and there are no valves, ports, et cetera to prevent rapid and complete unloading of heavy mixtures.

Write for Illustrated Literature

THE CAVINS CO.
2853 Cherry Avenue
LONG BEACH, CALIFORNIA

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Improved Pipe Wiper

SINCE introducing the large rubber pipe wiper several months ago, engineers of Patterson-Ballagh Corporation have made an improvement in the product. Because of the size of the disk, use of a solid, molded piece of rubber prevents the driller from observing the mud level in the casing. Therefore, the product has been redesigned with large peek holes so that the operator can watch the mud level drop when swabbing.

This pipe wiper is made in five sizes, diameters ranging from 9½ in. to 19 in., to fit any size drill pipe. Because of its flexible center, it cleanly wipes mud or muck from the drill pipe and does not hinder collars and protectors from coming up through the wiper, it is stated. This improved wiper is made from specially molded rubber, reinforced at the periphery by a flat metal inserted disk. No metal is exposed. By designing windows in the web, there is a saving in weight, but no reduction in the strength of the rubber. The wiper is placed under the rotary table.

Further details may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

Brown Protectoglo, Photo-Electrode System

THE Brown Instrument Company, a division of Minneapolis-Honeywell Regulator Company, Philadelphia, Pennsylvania, announces what it asserts is a safe and reliable method of protection against failure of oil, powdered coal, and luminous gas flames by the recently developed Brown Protectoglo, Photo-Electrode System.

The photo-electric principle used in the new unit avoids the necessity of placing a metallic electrode in the high-temperature flames, but retains the quick response feature that is characteristic of thermionic systems.

The function and operation of the photo-electrode is quite similar to the familiar Brown Flame-Electrode Protectoglo System. The principle difference lies in its method of flame detection. Instead of using a metallic electrode, the Brown Protectoglo, Photo-Electrode System detects the presence of a flame by means of the light emitted when a burner is in normal operation.

The heart of the system is essentially a light-sensitive device. In operation, the light from the flame is directed upon a photo cell. This results in a small flow of current through the cell, which is amplified by a vacuum tube circuit until of sufficient magnitude to close a relay. Through the relay contacts, the main fuel valve is energized.

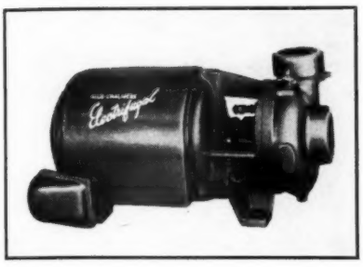
A new bulletin, No. 96-1, completely describing this new unit has just been issued. Those desiring a copy should address their request to The Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pennsylvania.

Allis-Chalmers Electrifugal Pump

ALLIS-CHALMERS Manufacturing Company, Milwaukee, Wisconsin, announces its new "Electrifugal" pump, which is an all-in-one centrifugal pump especially designed as a complete pump and motor unit on one shaft and in one housing. Instead of using standard motors having special end housings and shaft extensions, the "Electrifugal" pumping unit has a special motor with a one-

piece cast-iron motor yoke and pump bracket. The feet are cast integral with the housing and bracket and extend under the entire unit instead of under the motor only.

The special motor design, with copper bearing steel cover, meets NEMA specifications for splashproof motors. Totally-enclosed, fan-cooled motors and explosionproof motors are also available in the "Electrifugal" type.



In splashproof construction the "Electrifugal" pump is now available in sizes from 1 hp. to 10 hp., inclusive, at 3500 r.p.m. and from ¾ hp. to 7½ hp., inclusive, at 1750 r.p.m. for heads to 160 ft. Larger sizes of this type are in the process of design.

For normal service the pump is built with cast-iron casing, bronze fitted. It can, however, be made all-iron, all-bronze, all-stainless-steel, or of other special metals to suit any industry. In the chemical industry the sheet metal motor cover can be made of stainless steel to provide the longest possible complete unit life on any particular installation. Bulletin B-6040 is available on request.

New Bronze Globe Valve

A NEW Bronze Globe Valve, Figure 531-P, has been announced by the Reading-Pratt and Cady Division of the American Chain and Cable Company, Inc., Reading, Pennsylvania. This valve has a full-plug type seat and disk, designed for throttling services on high-temperature and high-pressure steam lines. It is also suitable for use on high-pressure lines carrying boiler scales and other gritty substances that quickly wear ordinary seating materials.

The body is made of a special hard bronze, disk and seat of heat-treated stainless steel, 500 Brinell hardness, and the stem is of high-strength wear-resisting bronze.

Literature describing the valve will be sent on request.

You can't judge

PISTON RINGS *by looks*

. . . any more than you can judge tires.

ONE tire is good for only 15,000 miles; another is good for 40,000 miles. Yet you can't tell the difference by looking at them. There are invisible ingredients in the good tire that account for its vastly superior performance.

The same is true of piston rings. You can't judge their performance ability by looks. The marked superiority of COOK'S Rings in the vital matter of performance originates in the fact that they are engineered especially to meet the service requirements of the specific engine or compressor in which they are to be used—a procedure made possible by Cook specializing in the manufacture of custom made rings for the equipment builders and operators who appreciate that performance counts, and that the best rings are ultimately the most economical to use.

The best proof of the superiority of COOK'S Rings is the fact that many manufacturers have turned to COOK'S Rings for their severe service units while confining the use of ordinary rings to machines on which demands are light.

But more and more engineers are beginning to realize the slight added cost of COOK'S GRAPHITIC IRON Piston Rings is low-cost insurance against the occasional trouble that develops from impaired lubrication, presence of extraneous matter or from any one of a number of causes that result in costly shutdowns and repairs.

★ ★ ★

The full story behind COOK'S Rings is yours for the asking. Write for it today and learn about COOK'S GRAPHITIC IRON—COOK'S "TINIZING" process which provides preconditioned wearing surfaces —and COOKMET— all exclusive in COOK'S Rings and which have contributed so much toward improving engine and compressor performance.

. . . It pays to use

COOK'S GRAPHITIC IRON PISTON RINGS

C. LEE COOK MANUFACTURING CO.

INCORPORATED

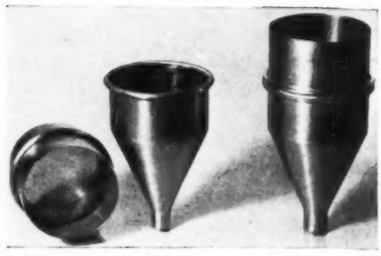
New York Los Angeles Cleveland Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

Baroid Screen Set

THE Baroid Sales Division, Los Angeles, California, now has available its new Baroid Screen Set. This equipment provides a simple and extremely accurate means of determining the sand content of drilling mud.

A special 200-mesh sieve 2½-in. in diameter, a funnel to fit, and either an elutriation tube or a centrifuge tube comprise the entire equipment. Consequently there is no complicated assembling or dismantling necessary, the final results can be obtained rapidly, and the very simplicity of the apparatus minimizes the possibility of error not only in running the tests but in taking readings, the manufacturer asserts.

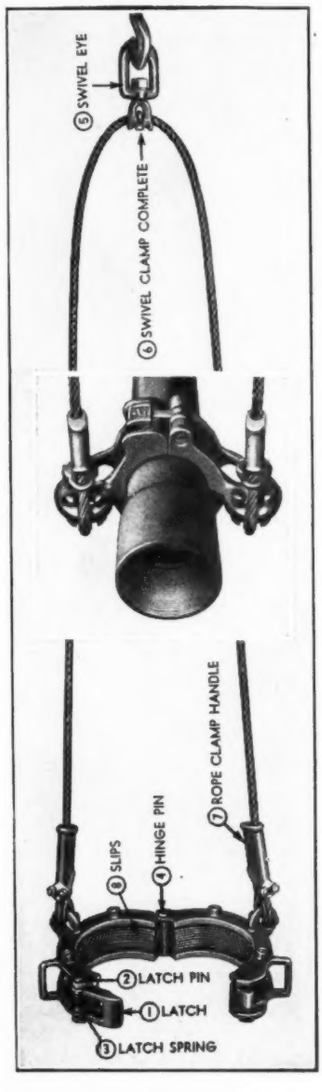
The elutriation method, which has been the standard means of determining sand content, is quite practical but is susceptible to error because frequently particles, although finer than 200 mesh but having a specific gravity greater than 2.7, are not separated-out by the wash water, it is stated. As a consequence these particles remain



with the sand particles and thereby cause a higher reading of the sand content than is actually the case; however, the very method of operation of the Baroid Screen Set eliminates this chance of error, it is asserted. Furthermore, no calibration or readjustments are necessary to keep the apparatus in working order.

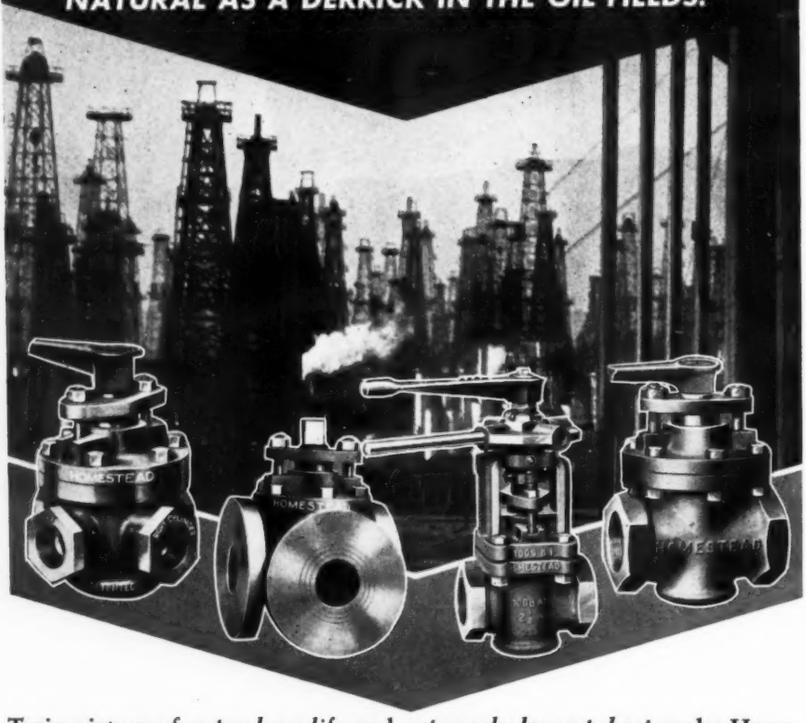
BJ Elevator For "Tailing-In"

THE Byron Jackson Elevator for "tailing-in" single joints of external upset casing eliminates use of the rope sling and prevents the pipe

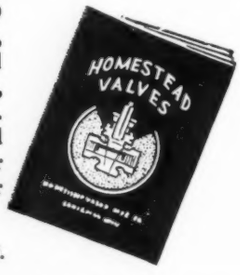


HOMESTEAD VALVES

NATURAL AS A DERRICK IN THE OIL FIELDS!



Twin virtues of *extra long life* and *extremely low up-keep* make Homestead Valves a natural selection for fluid control in the producing and refining industries. Outstanding performance such as that of 30-8" and 4" Homestead Valves serving for 12 years on temperatures to 1120° F. and pressures to 200 pounds, or 42-6" Valves on hot tar for 15 years, is due to "built-in" features, such as protected seating surfaces, positive cam or lever sealing, straight line flow, and quick opening or closing. That's why engineers and operators who build their pipe lines, refineries and production units for lowest cost per year operation, specify and order Homestead Valves.



HOMESTEAD VALVE MFG. CO. P. O. Box 14 Coraopolis, Pa.

HOMESTEAD VALVES

Send for Reference Book No. 38; and for special prices on your quantity valve requirements.

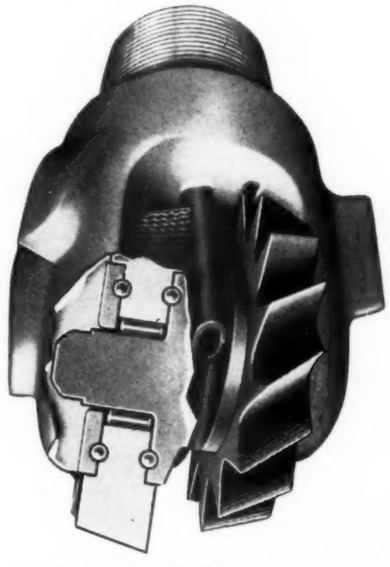
from slipping or falling with damage to the pipe or injury to the crew, according to the manufacturer, Byron Jackson Company, Los Angeles. The Type P elevator is made in halves, hinged at the center, and latched opposite the hinge by a sturdy stirrup-type latch. The bore of the elevator contains slips set to receive a 5 deg. tapered external upset casing joint.

A flexible wire-line bail having a clamp and swivel at the top keeps the elevator in a true, balanced position, and the ends of the wire line are protected by hand guards. The free-spinning swivel on the clamp has an eye sufficiently large to accommodate any desired means of attaching it to the hook or hoisting elevator.

The Type P elevator is used as follows: When the slips are being set in the spider (after the previous joint has been set in the hole) one of the crew closes the elevator around the next joint on the derrick floor. Then, when the block and hook are raised, the joint of pipe is lifted to the required height where it hangs in a true vertical position so that the pin may be easily and safely lowered into the coupling without danger of developing a cross-thread.

Grant Roller-Cutter Shale Bit

THE Grant Oil Tool Company is introducing its new Roller-Cutter Shale Bit. This bit utilizes a cutting effect rather than a grinding method, and the manufacturer asserts this results in increased drilling speed and reduction in drilling costs.



It is stated by the makers that an outstanding feature of this new bit is that it takes full advantage of the hydraulic principle. This is done by having two center flow beans extend to the bottom of the bit, thus allowing circulation to strike the bottom of the hole without interference. In addition, the circulation is also directed over each cutter.

Another feature is the design that provides a maximum safety element, making it virtually impossible to lose a cutter or any other working part, according to the manufacturer. This is due to the ruggedness of the trunnion assembly and the large bearing surfaces. The trunnion is an eccentric type of one-piece construction that supports both cutters from leg to leg. Streamlining in design avoids excessive friction and allows maximum flow of returns, it is stated.

Cutters are extra large and properly hardsurfaced for long wear, and are designed to utilize both roller bearings for thrust and ball bearings to take the radial pressure, thus providing ample strength under the hardest going. Specially designed cutters are available for each type of shale formation. Dull cutter assemblies are easily removed and replaced.

The bit is available in a full range of sizes. Complete data may be obtained from the Grant Oil Tool Company, 2042 East Vernon Avenue, Los Angeles, California, or its export office at 30 Rockefeller Plaza, New York.

Why are so many new rigs FACTORY-EQUIPPED with J-M 420 ROTARY LINING?

Leading makers of rotary rigs prefer this tough lining because it provides these important advantages wherever used:

UNUSUALLY EVEN FEED-OFF, giving better control of braking...

HIGHER BRAKING EFFICIENCY, even at extreme temperatures caused by heavy loads...

LONGER LIFE, under any operating conditions...

LESS RIM SCORING, making drums last longer...

For the same reasons, J-M 420 Rotary Lining is the first choice of many producers whenever replacements are necessary. For complete information on this durable lining and details on all J-M Friction Materials, write Johns-Manville, 22 East 40th Street, New York, N. Y.

JM Johns-Manville 420 ROTARY LINING

Guiberson Type "H" Drilling Head

THE Guiberson Corporation, Dallas, Texas, has announced a new drilling head designated as the Type "H". This drilling head is of special interest to producers and drillers because it can be used both in cleanout work and drilling. In general purpose the head is similar to other Guiberson drilling heads, but the Type "H" has the advantage of a self-contained rotary table, incorporating as an integral part of the head the essential elements of a rotary table—kelly bushings, slips, and slip bowl. The kelly is rotated by a kelly bushing and core, which are revolved by a special built-in shaft.

The Type "H" drilling head provides a positive, leak-proof pack-off while drilling and also when running drill pipe or tubing, the manufacturers state. A rubber packing medium effects a tight seal around any standard kelly, either square, hexagon or fluted, from 2½ in. to 3½ in., as well as around tubing, drill pipe, collars, and tool joints to a maximum O. D. of 3½ in. The pack-off is equally efficient either in running-in or coming-out of the hole, it is stated. A characteristic of this head, as well as all Guiberson heads, is the built-in blowout preventer and stripper combination.

Power can be delivered to the driveshaft through a flexible coupling or universal joint from a gas engine, electric motor or drawworks shaft. Direct transmission or V-belts can be used, depending entirely on the speed of the driving element and the speed desired of the drilling head. The drivershaft is provided with a 12-tooth pinion that drives a 48-tooth ring gear on the drilling head core, providing the head with a 4-to-1 gear ratio.

The head is sturdily constructed, light in weight, and small in size, being only 41½ in. high.

Fisher Intermitter

THE Fisher Governor Company, Marshalltown, Iowa, has announced its new intermitter for time cycle control of oil and gas production. Features emphasized in this new unit are: the enclosing of the pilot and clock assembly in a weatherproof, gas-tight case of high-tensile iron, which is cast integral with the upper diaphragm casing. This assures dependable services in field installations where the unit is out in the weather, the manufacturers state. Compactness of the entire assembly is another feature. Length and frequency of operating intervals may be easily

Fisher Intermitter Type 4655-A

Fig. 1: The Grizzly Pressure Seal Seepage of fluid into clearance between Adapter "A" and Coupling flange "B" at "C" forces the specially designed terminal of hose body firmly against the adapter and coupling walls at "D" and "E" and forms a positive automatic seal at any pressure. This eliminates the old method of resorting to mechanical pressure to obtain a seal which eventually damages the hose beyond repair. Ample clearance between adapter and coupling flange eliminates any possibility of pinching or damaging hose.

Fig. 2: The Grizzly Adapter "A" is recessed to accommodate the end of the Hose "B" which is built integral with the Coupling "C". Both the Adapter and Coupling Flange are precision machined to perfect fit. The steel-to-steel connection between Adapter and Coupling positively prevents damaging hose in any manner.

Grizzly Pressure Seal Rotary Hose is carefully engineered to withstand *all drilling* pressures . . . from pressures that are practically nil to the highest pressures involved in drilling the world's deepest wells. Its exceptional performance is due to the patented Grizzly *Pressure Seal* Coupling, built integral with the hose and its steel armor; plus the super strength and flexibility of Grizzly hose, steel armored throughout the full length and diameter of the hose body.

The Grizzly *Pressure Seal* Coupling incorporates an entirely new and different method of sealing off the fluid within, as shown by the illustrations.

Complete details will be furnished upon request. Ask your supply house, or write direct, for Bulletin No. 20-OF.

E. M. SMITH COMPANY
860-650 South Clarence St., Los Angeles, California
Complete Stocks Maintained In Our Warehouses At:
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1008 S. E. 29th Street, Oklahoma City, Okla.
Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York
Distributed By Leading Supply Companies

GRIZZLY
Pressure Sealed ROTARY HOSE

varied to meet all individual requirements.

Fisher intermitters, the manufacturers point out, are widely used in all gas and oil producing areas for intermittent control of gas-lifting operations; automatic "stop-cocking" of high gas-oil ratio wells or distillate wells; controlling production periods of wells under proration, controlling high-pressure operating mediums to production devices.

Bulletin No. 80-C gives complete specifications and prices on this new intermitter. Write Fisher Governor Company, Marshalltown, for a copy.

Link-Belt "Friction Fighter" Bearings

REALIZING the difficulties encountered in trying to distinguish between the series numbers assigned to the various types of anti-friction bearing units, Link-Belt Company, Indianapolis, Indiana, is humanizing the presentation of its five types

by comparing them with prize fighters and re-classifying the group according to the various weights of fighters known to the ring.

The five different types are: Series 100 ball bearings, and Series 400, 500, 600, and 7200 self-aligning roller bearings.

The new classifications decided upon are: Flyweight for the Series 100; Welterweight, Series 400; Middleweight, Series 500; Heavyweight, Series 600, and Alternate Heavyweight, Series 7200.

The entire line of bearings will be known as Link-Belt "Friction Fighter" bearings, as the term friction fighter so aptly describes a characteristic of the anti-friction bearing, the manufacturer asserts.

Transmitting power is essential to both the fight game and industry. A prize fighter can see his opponent, and transmits powerful punches in an attempt to bring him to the floor. But in industry, there is the invisible opponent, friction. This invisible opponent fights wherever shafts go into their rounds, and no matter how badly he may be licked, he'll always make a comeback.

To obtain more detailed information on Link-Belt's Friction Fighter bearing units—descriptive matter, illustrations, dimensions, list prices, weights, engineering data—readers interested in the use of such bearings should send for a copy of a new 88-page Data Book No. 1775, giving all this information and classifying the five types of bearings as hereinbefore indicated. The book is free for the asking, and the request may be addressed to the nearest office of the company.

Marked Shim Stock

THIN shim stock supplied in slotted cartons by Laminated Shim Company, Inc., Glenbrook, Connecticut, now is supplied plainly marked in inches on its edge—from 0 in. to 100 in., with half-inch subdivisions throughout the 100-in. length—at no extra price.

Therefore, the precision-thin metal can be conveniently pulled through the carton slot and cut-off to the exact size required.

"GETS YOU THERE AND BACK"
Regardless of Conditions Under Foot...

The one thing that causes more cussing, than any other, in oil field operations, is breakdowns in transportation. Trucks that spin their wheels and get stuck after every rain, or give up the ghost every time they have loose sand or gravel to get through, simply cannot be tolerated. Trucks that "cannot make the grade" if the going is a little up-hill get very little sympathy from the operating crew. . . . That's why Marmon-Herrington heavy duty *All-Wheel-Drive* trucks and converted Fords are being used, increasingly each year, by all major companies and independents. *These trucks really do the job.* Write for literature. Cable address MARTON.

MARMON-HERRINGTON COMPANY, INC.
INDIANAPOLIS, INDIANA, U.S.A.

Ideal Rotary Connector

THE wide acceptance and universal approval of operators using the Ideal Type DA-30 Rotary Connector on heavy-duty rotary rigs has prompted the National Supply Company, Toledo, Ohio, to develop its Type D-6 Connector for lighter rotary use, according to a statement by company officials.

In use, the connector replaces the conventional rotary hook with a yoke from which elevator links can be independently suspended. Drill pipe is handled in the usual manner, and a special adapter, which is easily attached to the swivel bail, provides a means of carrying the swivel with the regular elevator when drilling.

The arrangement of carrying the elevator links independently of each other makes for increased flexibility in handling the elevator when running drill pipe, greatly facilitating opening and closing of the elevator, whereas vertical suspension of each link provides a better balance of the loads on the elevator.

Carrying the swivel below the elevator links has decided advantages, it is pointed out. It eliminates the practice of the links resting and pounding against the swivel, and there is no chance of the links bumping against the swivel bail or interfering with the rotary hose. The arrangement is especially applicable to drilling with portable masts. As the links are vertical at all times, they are not suspended at an angle, but are a part of a streamlined assembly that offers no interference with the mast structure.

The Type D-6 Connector is very compact, with an overall width of only 18¾ in. and an overall length of 72 in., and its 60-ton capacity makes it ideal for the rotary drilling of moderate-depth wells, it is asserted.

Construction details, photos, and diagrams are shown in Bulletin No. 266, a copy of which will be mailed upon request.

$30 Saves Driller $300.00

...using PATTERSON-BALLAGH PIPE WIPER

"Besides wiping the pipe, one of my Patterson-Ballagh Pipe Wipers saved me two fishing jobs," reports one of the best known Drilling Superintendents in West Texas. "The fishing jobs would have cost me at least $150.00 each. Two elevator bolts dropped through the table and we picked them up on the Pipe Wiper. Each would have cost us at least one trip into the hole." This Operator has drilled more than 200 wells in West Texas and equips all his rigs with Patterson-Ballagh Pipe Wipers, both going in and coming out of the hole. These Pipe Wipers will save you a lot of grief. Try them.

For Further Savings, Use Patterson-Ballagh Protectors

PATTERSON-BALLAGH CORPORATION

Los Angeles Houston New York City

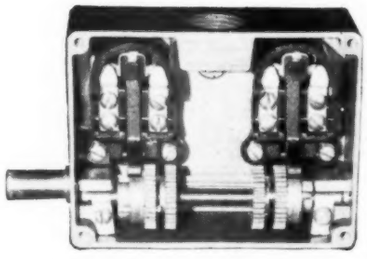
Geared-Type Limit Switch By General Electric

A new, small-size geared-type limit switch has been announced by General Electric Company, Schenectady, New York, for application on motor-driven devices where it is necessary to limit the rotation of the motor shaft or some rotating shaft or gear on the driven machine. The small size of the new switch is shown by

its dimensions: $4\frac{1}{16}$ by $3\frac{1}{2}$ by $1\frac{29}{32}$ in.

In use, the shaft of the switch (which is usually directly connected to an electric motor) serves as a driving gear, causing the pinionshaft to turn. The pinionshaft engages the driving gears, which move along the drive screw toward one of the operating gears at either end, depending on the way they are turned by rotation of the pinionshaft. For one adjustment, the traveling gears maintain a constant space between them.

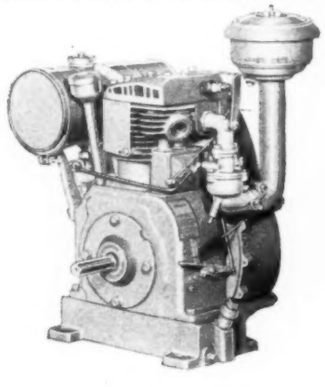
At the end of travel in either direction, a pin on the traveling gear engages a pin on the operating gear. This causes the operating gear, cam, and safety pin, which are a unit, to rotate and move the switch contact arm to a high part of the cam, operating the contacts. These contacts are designed for 125-v., 4-amp., a-c. operation and 125-v., 1 amp., d-c operation.



Some of the features of the new switch are double-break, fine-silver contacts that clean themselves with a rocking motion; a mechanism easily adjusted to operate contacts between a minimum of ½ turn of the driving shaft to a maximum of 120 turns (an overtravel of $3\frac{1}{2}$ turns is provided to prevent accidental damage to switch mechanism), and three holes in the base by which the switch may be mounted in any position desirable for attachment of the shaft.

Industrial Motor

THE Briggs and Stratton Corporation, Milwaukee, Wisconsin, has announced a new 4-cycle, air-cooled gasoline motor, known as Model "ZZ."



Although rated at 6 hp., the actual hp. output in the recommended speed range, as recorded in dynamometer tests, is 6.15 hp. at 2200 r.p.m., 7.20 hp. at 2700 r.p.m., and 7.70 hp. at 3200 r.p.m.

Piston displacement is 22.97 cu. in. with a 3 by $3\frac{1}{4}$ in. bore and stroke. Ignition is supplied by a specially designed dust- and moisture-proof high-tension flywheel magneto. Other standard equipment includes: silchrome exhaust valve with alloy-steel inserted seat, inserted molybdenum alloy valve guides, specially designed float feed type carburetor, adjustable mechanical governor, drop-forged counterweighted crankshaft, aluminum alloy pistons and connecting rods, pump and splash lubricating system, gasoline filter, oil-bath air cleaner, screened blower housing, and other features.

The fuel tank capacity is $1\frac{1}{4}$ gal. and oil reservoir 5 pints. Overall dimensions are: height 25 in., width 20 in., and depth 22 in. Net weight with crank starter is 134 lb.; with rope starter, 129 lb.

Front and side views of the McEvoy "Fluid Weight" Gas Lift.

How You Can Recover Oil at a

LOWER COST PER BARREL

You reduce lifting cost in three ways with the new McEvoy "Fluid Weight" Gas Lift.

1. **You Save Gas:** In one well gas-lifting efficiency was increased 429%. A 216% increase in efficiency was observed in another well. This outstanding economy results from the most efficient use of every cubic foot of gas. No leakage from upper valves. The lowest valve uncovered by the fluid in the well is the *only* valve admitting gas.
2. **You Save on Upkeep Cost.** To regulate the well's production you simply regulate input gas pressure with a positive choke. That's all — No delicate controls to get out of order or require frequent attention. Just control the flow as you would a flowing well.

   Sand traps, screens and check valves protect vital parts from clogging and sand cutting. Corrosion resistant materials are used to eliminate corrosion troubles. You are sure of lowest upkeep cost with the McEvoy Gas Lift.
3. **You Save on First Cost.** A simple intermitter type gas lift for the East Texas field costs only about $300.00 (production packers and liner chamber extra). Costs are correspondingly low for your well. The entirely new operating principle makes possible the elimination of expensive surface equipment. Wider spacing of valves reduces the number of valves required. These features combine with many others to reduce the first cost of this outstanding gas lift.

Why not learn more about this money-saving way of lifting oil? Over two years' field service has proved the McEvoy "Fluid Weight" Gas Lift to be simple to operate, dependable and consistently economical. Phone, write or wire McEvoy Company or ask your nearest McEvoy representative for full details on this remarkable gas lift.

SEE McEvoy Section of 20 PAGES in the Composite Catalog

McEVOY COMPANY
TEXAS AT MILBY
HOUSTON, TEXAS
EXPORT OFFICE: 30 CHURCH ST., NEW YORK

Condor Whipcord Endless Belts

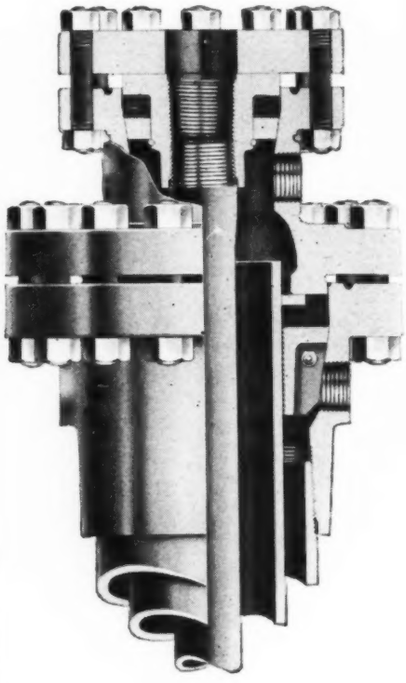
DUE to the growing use of short, flat endless belts on short-center and pivoted-motor-base drives, The Manhattan Rubber Manufacturing Division of Raybestos-Manhattan, Inc., Passaic, New Jersey, announces the Condor Whipcord Endless Belts are now available from stock for prompt shipment in a number of sizes and in two styles. The two styles that are carried in stock are capable of handling drives from ¼ to 25 hp. and are applicable to more than 1500 different drives, it is asserted.

Cameron Low-Pressure Casing and Tubing Heads

CAMERON Iron Works, Inc., Houston, Texas, who have developed numerous oil-tool specialties for the control and completion of high-pressure wells, have entered the low-pressure field with a new series of low-cost, 1000-lb. working pressure well heads.

In announcing its line of low-cost, low-pressure casing and tubing heads, the manufacturer points out that several of their mechanical features have only been available heretofore in the higher pressure, more costly well heads. Mass production methods of manufacture, made possible by the company's modern plant at Houston, accounts for the low price of these new casing and tubing heads, it is asserted.

The accompanying cross-sectional drawing of an assembly of Cameron



low-pressure casing and tubing head illustrates the following mechanical features: (1) forged-steel casinghead housings; (2) Standard A.P.I. flanges on both casinghead and tubinghead to permit the use of blowout preventer equipment if required; (3) slip suspension of casing; (4) neoprene-asbestos packing above the slips, which may be tightened externally at any time; (5) self-sealing tubing hanger with neoprene-asbestos packing, which also may be tightened externally at any time; (6) nested design that results in an extremely low overall height and thus conserves cellar space.

In addition to the Type "UA" self-sealing threaded suspension type tubing hanger illustrated, three additional types of tubing hangers are available, all of which are readily interchangeable in a single tubinghead housing; Type "R" Tubing Collar Type Suspension; Type "Q" Slip Suspension, and Type "RA" Slip Suspension with packoff below the slips.

Fully descriptive literature, including prices and dimensional data, will be sent on request. Address the manufacturer at 711 Milby Street, Houston, Texas.

WE APPRECIATE WHAT OIL MEN HAVE DONE FOR US

Many of our best accounts are those of oil men. We appreciate the fact that the business they have entrusted to us has helped materially to build this bank —the largest in Texas. In turn, we try to show our appreciation by handling their loan problems sympathetically and with an earnest desire to cooperate.

FIRST NATIONAL BANK IN DALLAS MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

H. G. Kieswetter on Trip to South America

About to leave for Brazil and Argentina, Herbert G. Kieswetter (left), of United States Rubber Export Company, Ltd., chats with John D. Clarke (right) of the same organization. Both men are regional sales directors for U. S. Rubber Export.

After a trip by rail from New York, Mr. Kieswetter flew from Miami, Florida, via Pan-American, with stops at Rio de Janeiro, Sao Paulo, and Buenos Aires. During his stay of several weeks in the Argentine he will meet with local oil company officials and visit the oil fields.

W. M. Black President American Manganese Steel Division

W. M. BLACK

W. B. Given, Jr., president of the American Brake Shoe and Foundry Company, announces the appointment of W. M. Black as president of the company's American Manganese Steel Division.

Black became general sales manager of this division in 1934 and a vice-president in 1935. He has been with "Amsco" since 1912, with the exception of the war years, when he served as a lieutenant in the U. S. Ordnance Department.

The American Manganese Steel Division was formerly headed by W. E. Crocombe, who remains president of the American Forge Division of the company.

Twin Disc Opens St. Louis Branch

The Twin Disc Clutch Company, Racine, Wisconsin, on November 1 opened a new branch office in St. Louis, Missouri.

Opening of this new office, which is situated at 1701 Delmar Boulevard, greatly extends service, parts and engineering facilities to operaters of Twin Disc products in this territory. Henry Wirry, of the Twin Disc factory engineering staff, is stationed at the new office to handle sales and engineering.

WINTER COMING
SURFACE CONTROLS can't FREEZE with
OTIS REMOVABLE BOTTOM HOLE REGULATOR ON THE JOB
Cold weather is coming... protect your wells with an Otis Removable Bottom Hole Regulator. It positively eliminates freezing of surface controls. Costly heaters are no longer needed. Tubing pressures are reduced to safe workable limits. Regardless of the extremity of the well pressure; high or low rates of withdrawal can be made under a low delivery pressure, merely by adjusting the surface choke.
Simple in operation...well pressure acts against the movable valve seat, which in turn acts against the regulating spring. This upward travel of the valve seat above the stationary valve permits flowing up through the orifice in valve seat. The distance the valve seat rises is controlled by the pressure differential across the valve seat acting up against the mechanical load of the spring. This load is predetermined and governed by the thickness of the adjusting ring.
Otis Service is available in most major oil fields, for immediate installation of regulators. Installation is made under pressure by an ordinary steel measuring line.
The outstanding economy and safety of the Otis Removable Bottom Hole Regulator accounts for its increasing popularity... over 250 regulators have already been installed, many of which have been in continuous use over a year.
OTIS "Don't Kill Your Well" Call PRESSURE CONTROL OTIS SERVICE - EQUIPMENT
OTIS PRESSURE CONTROL, Inc.
DALLAS, TEXAS
1. Slips
2. Sealing Cups
3. Adjusting Ring
4. Regulating Spring
5. Movable Valve Seat
6. Valve

G. W. Martin and F. A. Garrett Promoted

GEO. W. MARTIN

George W. Martin has been appointed general superintendent and Fred A. Garrett purchasing agent and building manager for the Dallas Gas Company and the County Gas Company, Dallas, Texas, affiliates of the

FRED A. GARRETT

Lone Star Gas Company, it has been announced by R. G. Soper, president and general manager.

Martin, formerly assistant general superintendent, purchasing agent, and building manager, succeeds R. M. Redding, who has resigned because of ill health. Garrett formerly was assistant purchasing agent.

Dow Chemical Company Holds Conference

Two hundred representatives of The Dow Chemical Company, and their wives, from Canada, Mexico, and various parts of the United States, held their sales conference with company executives at the general offices in Midland, Michigan, November 13-16. All meetings were in charge of Leland I. Doan, vice-president and general sales manager.

Special cars from New York, Chicago, St. Louis, and the West Coast brought the guests to Detroit, where a special train transported the party to Midland.

General sales policies were discussed, the better to acquaint representatives with the company's recent significant developments.

Headlining the activities of the conference was a two-day session devoted to discussion and motion pictures of the company's progress. This meeting featured plants that have recently been completed and new products that have been added to Dow's line.

"The last two years have been a period of growth for us," said Doan. "Under such conditions it is easy for a widely scattered sales personnel to lose touch with late developments. This conference gave Dow men an opportunity to receive the composite picture of our latest developments and at the same time enabled us to have a good old-fashioned family reunion to renew old friendships. Divisional sales conferences following the general session also proved helpful to the various departments and made possible a further coördination of all sales activities."

Representatives and officers who discussed operations and product developments were: Dr. Willard H. Dow, president and general manager; Earl W. Bennett, vice-president, secretary and treasurer; R. L. Curtis, general manager, and J. F. Smith, sales manager of Dow's Great Western Division; Dr. D. T. Prendergast, Iodine and Insecticide Division, Long Beach, California; Dr. Jose Polak of Dowell Sociedad Anonima, Mexico City, Mexico; N. R. Crawford, vice-president and general manager of Dowell Incorporated, Tulsa, Oklahoma; L. C. Stewart, Technical Research Department, Midland; M. E. Putnam, president, Cliffs Dow Chemical Company, Marquette, Michigan.

Worthington Enters Water-Purification Field

In connection with its entrance into the water-purification field, the Worthington Pump and Machinery Corporation of Harrison, New Jersey, announces that it has completed research and design standards for hot process water softeners and pressure filters for all capacities.

Worthington's chemical and other technical departments, as well as its manufacturing facilities, have been supplemented to accommodate the particular requirements of water-purification service, it is announced.

It is stated by the corporation that the new design, in combination with heaters and other water-handling equipment of its manufacture, incorporate certain advantages hitherto unavailable. Worthington bulletins W-210-B26 and W-210-B27 describe this filter line.

Johns-Manville Expands

A $625,000 expansion program is announced by Johns-Manville. The program will include the installation of manufacturing equipment in the recently acquired plant at Zelienople, Pennsylvania, and the building of new warehouses at the company's plants at Nashua, New Hampshire, and Richmond, Indiana, the announcement said.

Mike Murphy Killed in Crash

W. Mike Murphy, operations manager for the Louisiana-Nevada Transit Company, Hope, Arkansas, died

MIKE MURPHY

Thursday, October 31, as the result of injuries sustained the previous Monday when his car collided with a two-car motor transport in a dense fog. Although his business office was in Hope, he maintained his residence in Dallas, Texas.

Murphy was well known in the industry, having been an engineer with the North Texas Gas Company, construction superintendent of pipe lines for the Magnolia Gas Company, and consulting pipe line engineer for Air Reduction Sales Company, prior to joining Louisiana-Nevada a little more than a year ago.

A veteran of the World War, he organized a company of infantry at Quanah, Texas, where he had moved from Lewiston, Maine, as a boy, and served as its Lieutenant in the Thirty-Sixth Division. He was wounded in action in the Argonne and received military decorations from France and the United States.

Murphy was a graduate of Quanah High School and the Texas A. & M. College.

Surviving are his widow; two daughters, Patricia and Catherine; and a son, Michael, Jr., and two brothers, J. W. (Pat) Murphy and Martin Murphy, all of Dallas.

H. B. Thomas Enters Consulting Practice

H. B. THOMAS

Harold B. Thomas, one of the founders of the Elastic Stop Nut Corporation, Union, New Jersey, and vice-president in charge of sales, has resigned to enter consulting work in industrial product analysis and market research. He remains active as a director and member of the executive committee of the corporation.

A.S.M.E. Meeting Expected to Attract 5000

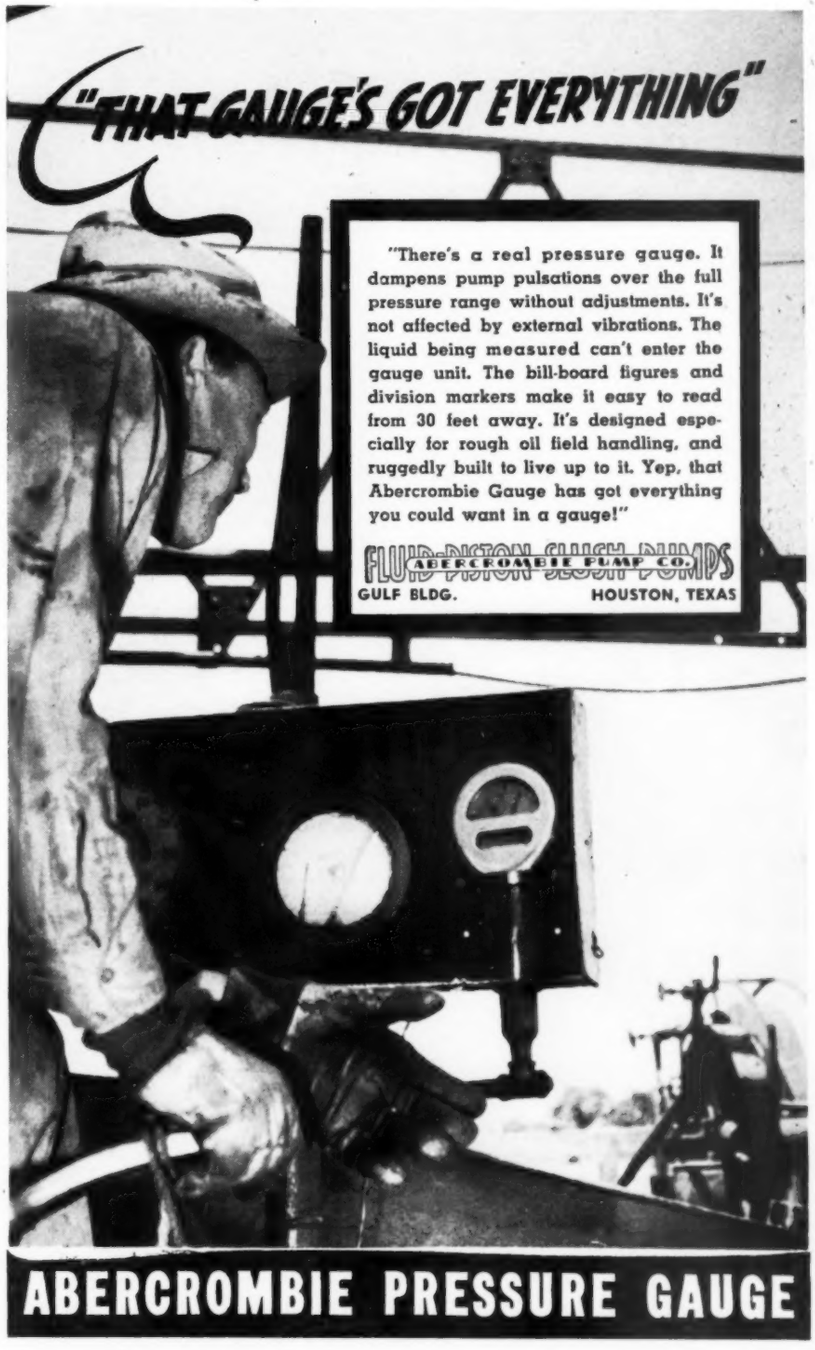
Keynoting better living and greater industrial progress through engineering, the Sixty-First Annual Meeting of The American Society of Mechanical Engineers, to be held in New York City, December 2-6, 1940, with meeting headquarters at the Hotel Astor instead of the Engineering Societies Building, is expected to attract to it about 5000 engineers and executives from the United States and Canada. More than 100 technical papers on such specialized mechanical-engineering subjects as aeronautics, applied mechanics, fuels, hydraulics, metals engineering, machine-shop practice, management, materials handling, petroleum, steam power, railroads, textiles, heat transfer, and process industries will be presented by leading experts in the field. To accommodate all these papers, 44 simultaneous sessions are being scheduled, including six on Monday evening, December 2.

The banquet on Wednesday evening, December 4, will feature two outstanding addresses, one by A.S.M.E. President Warren H. McBryde, San Francisco, California, and the second by a nationally famous member of the National Defense Commission. In addition, President McBryde will present to outstanding American engineers the 1940 awards of the Society, including the A.S.M.E. Medal, Holley Medal, Worcester Reed Warner Medal, Melville Medal, Junior Award, Pi Tau Sigma Award, Charles T. Main Award of $150, and two Student Awards of $25 each. Tuesday evening will be devoted to an informal, get-together smoker, and Thursday evening to college-reunion dinners.

Officers recently elected for 1941 by a letter ballot will be installed in office on Friday, December 6.

Joins Fields Foundation

Allen Whiteside, resigning as a director of the Sinclair Prairie Oil Company, announces he has accepted an invitation to become executive director of The Fields Foundation, a national organization engaged in the work of rehabilitating deserving paroled and discharged inmates of penal institutions.


"THAT GAUGE'S GOT EVERYTHING"
"There's a real pressure gauge. It dampens pump pulsations over the full pressure range without adjustments. It's not affected by external vibrations. The liquid being measured can't enter the gauge unit. The bill-board figures and division markers make it easy to read from 30 feet away. It's designed especially for rough oil field handling, and ruggedly built to live up to it. Yep, that Abercrombie Gauge has got everything you could want in a gauge!"
ABERCROMBIE PUMP CO.
GULF BLDG. HOUSTON, TEXAS
ABERCROMBIE PRESSURE GAUGE

Look for the Arm and Hammer

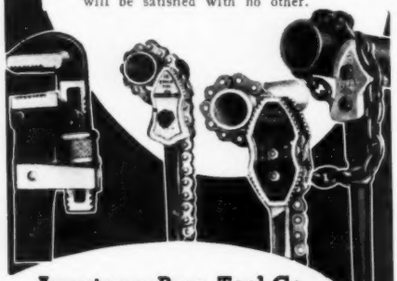
ARMSTRONG BROS.

PIPE TONGS

Not only the type Tongs you want in the size and design you prefer—but the quality that distinguishes an "ARMSTRONG BROS." PIPE TOOL.

Chain Tongs with handles forged from high carbon steel, Drop Forged jaws with milled teeth, hardened, tempered and tested for wearing qualities, large Hardened Steel Bolts, Alloy Steel Shackles, proof-tested Chains, and the ARMSTRONG Design that gives far more bearing of jaws on bar.

All-Steel Pipe Wrench. This patented all-steel pipe wrench has 10 improved features including—elimination of cumbersome housing. Heavy forged-in lugs reinforced by reversed nut to take up side strain. Replaceable tool steel jaws. Perfect balance in all sizes. Try one and you will be satisfied with no other.



Armstrong Bros. Tool Co.
"The Tool Holder People"
331 N. Francisco Ave., Chicago, U.S.A.
Eastern Warehouse and Sales
199 Lafayette Street New York

Now Available in Booklet Form

The Complete UREN Decimal System

(Including a Subject Index Arranged Alphabetically) for classifying and filing data pertaining to the Petroleum Industry. Only fifty cents a copy. Send your order to THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas, Texas.

Homco Cutting and Fishing Tool Service in New Building

Above—New office and shop of Homco Cutting and Fishing Tool Service. Right—Interior view of the warehouse

Homco Cutting and Fishing Tool Service, a division of Houston Oil Field Material Company, Houston, Texas, has recently moved into new heead-quarters, office and shop, at 2101 South Wayside Drive, Houston. The building, containing 15,000 sq. ft. of floor space, is a modern brick structure designed for maximum natural light, and all offices are air-conditioned. The location contains 4.7 acres.

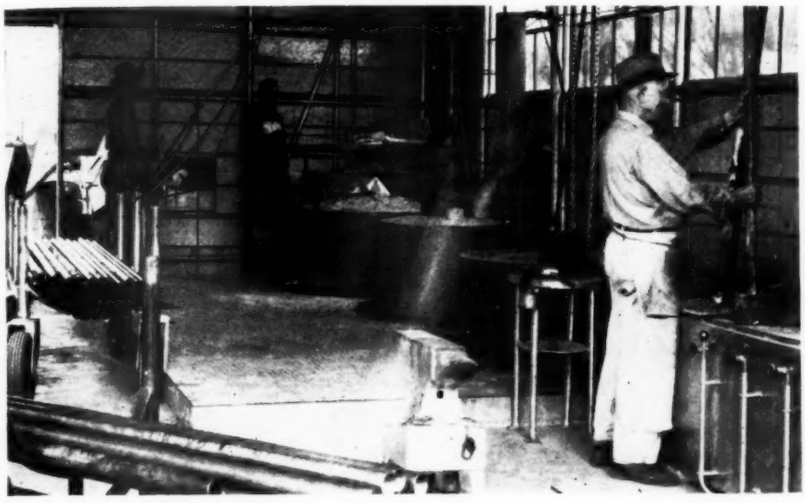
The modern shop, warehouse room for tools, and office allows the organization not only to do its own repair work, but to manufacture its own specialized cutting and fishing equipment. The Homco Side-Wall Sampler and the new Homco Jack Screw Cementing Packer are being manufactured in the new, completely equipped shop.

Removal of Homco Cutting and Fishing Tool Division to new quarters does not affect in any way the supply division or the specialty tool sales division of Houston Oil Field Material Company, which remain at 1524 Maury Street, Houston, the space vacated by the cutting and fishing tool division, giving them much needed room for expansion.

C. V. Millikan Honored by A.I.M.E.

C. V. Millikan, chief petroleum engineer of the Amerada Petroleum Corporation, Tulsa, Oklahoma, received a signal honor from the American Institute of Mining and Metallurgical Engineers at that organization's annual meeting in Tulsa recently. He was presented with a scroll signed by all the engineers attending the meeting in recognition of his work for the A.I.M.E. and for the industry as a whole. Paul Weaver, vice-president of the Humble Oil and Refining Company, made the presentation speech.

Fluid Packed Pump Company Heat-Treats Own Pump Barrels



Culminating more than two years of experimental development work, Fluid Packed Pump Company, Los Nietos, California, has recently completed a specially designed heat-treating plant that incorporates many advanced features. Arrangement of the furnaces, automatic controls, and other important improvements in heat-treating technique were especially developed by Fluid Packed Pump engineers to produce outstanding qualities in the new Fluid Packed one-piece pump barrels.

This new unit is the first installation of its type in the pump manufacturing industry, officers of the company state. Another recent development was the new type honing machine that makes possible the precision manufacture of one-piece alloy steel pump barrels. These barrels, which have no joints to bind or cause fluid leakage, are now being used in the new "Improved Insert" pump, as well as in the "Groove Seal" pump line.

Other important developments are also under way and will be announced soon, according to Fluid Packed Pump Company officials.

Brown Beaumont Representative McEvoy Company

HAROLD L. BROWN

McEvoy Company, Houston, Texas, has announced the appointment of Harold L. Brown as sales representative for the Beaumont area.

Brown is well qualified to service equipment buyers, having had valuable experience as a field man in the Gulf Coast area.

He is now at 2215 Avenue "A", Beaumont, Texas. The telephone is 4910.

George Bigelow Announces New Connection

Friends of George Bigelow, formerly president and general manager of Pacific Pump Works, will be interested to learn of his new connection and plans. Bigelow is now heading up the Universal Television Company, 1027 North Highland, Los Angeles, California, which is planning an ambitious manufacturing and distribution program in 1941.

The products of Universal Television include radiophones, distance measuring devices, and range finders. While much of this material fits into the aircraft field and is of interest to the defense program, the oil industry will find radiophones and similar equipment of practical use in the field, Bigelow believes.

Bigelow organized the Pacific Pump Works in 1923 and many of the early patents on centrifugal pumps were taken out in his name.

Doorless Phone Booth blots up NOISE

Inside walls are perforated metal, backed by a soft absorbent which blots up noise.

Used in
Pumping Stations ★ Refineries ★ Shops

How to Improve Your Phone Service

If the noise of engines, pumps, and other machinery interferes with your telephone service, there is an easy way to stop such interference. Merely install your telephones in Burgess Acousti-Booths.

The Burgess Acousti-Booth is no ordinary telephone booth. It has no doors, but it is lined with an acoustic lining that blots up noise as quickly as a blotter soaks up ink. Therefore, within the booth is a "zone of quiet" that surprises everyone who first steps into a Burgess Booth. In fact, the interior of the booth is so hushed that you can hear any telephone conversation clearly, no matter what noise is going on around you.

These booths are made of steel. They are easy to install . . easy to clean . . and easy to use. The absence of doors assures ample circulation of air at all times.

It will pay you to install Burgess Acousti-Booths in every telephone location which is noisy. Errors and misunderstandings are prevented, time is saved, and service is greatly improved. Write today for facts.

Mail Coupon for Free Booklet

Burgess Battery Company, Acoustic Division
Dept. L, 500 W. Huron St., Chicago

Please send Free booklet describing Burgess Doorless Acousti-Booth and how it makes telephoning easy in noisy places.

Name .....

Company .....

Address .....

BURGESS ACOUSTI-BOOTH
Manufactured under Burgess Patents

BURGESS

LUFKIN
CHROME FACE STEEL TAPES

Oilmen find the new Lufkin Chrome Face Steel Tapes perfectly suited to their needs because they're so durable and easy to read. Jet black figures stand out prominently against a satin chrome surface that's remarkably free of glare. The smooth chrome surface won't rust, crack, chip or peel, and is easy to clean. Your dealer has Chrome Face Tapes in stock now.

WRITE FOR FREE CATALOG

LUFKIN
SAGINAW, MICHIGAN · New York City
TAPES · RULES · PRECISION TOOLS

Stanolind Announces Promotions

A. W. PEAKE

A. W. Peake has been made president of the Stanolind Pipe Line Company and Ralph O. Dietler has been named president of the Stanolind Oil Purchasing Company. Robert S. Ellison, who has been president of both companies, retires.

Peake has been chairman of the board of the pipe line company. It is announced that the office of chairman of the board will be left open.

B. P. Sibole, vice-president of the pipe line company, has been named executive vice-president and will be the active executive head.

Dietler has been vice-president of the oil purchasing company. He will also continue as general manager of the crude oil purchasing department of Standard Oil Company of Indiana.

William G. Heltzel, general superintendent of the pipe line company, has been advanced to vice-president and his position filled by the promotion of J. B. Harshman, who has been master mechanic.

Henry Waters has been promoted from the position of executive assistant to that of vice-president of the Stanolind Oil Purchasing Company.

W-K-M Appointed Export Distributor by Larkin Packer

W-K-M Company, Inc., Houston, Texas, has been appointed exclusive export distributor for Larkin Packer Company, of St. Louis, Missouri. The Larkin line of cementing equipment, tubing and casing heads, casing spiders and clamps, casing centralizers, forged-steel seamless bull plugs and swage nipples, oil-well packers and sand pumps are well known to the trade the world over. W-K-M Company maintains one of the oldest established export sales organizations in the oil industry, with export headquarters at 74 Trinity Place, New York City, under the direction of G. M. Stewart, and full-time representatives regularly touring leading export points of operation.

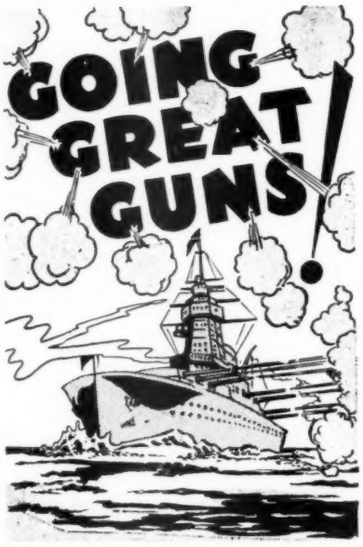
W-K-M Company has also been appointed exclusive distributor, both domestic and export, by the Hacker Machinery and Supply Company, of Turnertown, Texas. Hacker manufactures a line of snatch blocks, tubing blocks, a light rotary and swivel, boiler jacks and casing testing pumps.

C. R. Dale Joins Technical Staff of Totco

C. R. DALE

C. R. Dale, inventor and developer of many well-known instruments used in subsurface studies in oil fields, has consolidated his interests with those of Technical Oil Tool Corporation, Ltd., and will be actively engaged as a member of the technical staff in further invention and development work of a related nature, according to an announcement by J. B. Wood, president of the company.

Dale is well known for his development of oil-well surveying instruments and the Photoelectric Oil Well Water Locating Instrument, now widely employed in domestic and foreign fields, and is a practical authority on subsurface investigations of oil wells. Announcement will be made shortly of a new subsurface recording system that Dale has had in development for a considerable time and which has seen wide field application, principally in the continuous measurement of well temperatures and pressures. This recorder will be develeoped, manufactured, and marketed by the Technical Oil Tool Corporation.



Nothing stands still! All things must go forward or backward! Because of this fact we of the Affiliated National Hotels are literally "Going Great Guns" . . . having consistently blazed the trail of advancement through the first nine months of 1940.

The next big blast is scheduled with the opening of the New 250 room completely Air-Conditioned Hotel ADMIRAL SEMMES in Mobile, Alabama, in November, 1940. Thus, following the addition of Hotel GALVEZ at Galveston, Texas, and Hotel PLAZA at Laredo, Texas, we add further to the ever-growing list of Affiliated National Hotels.

* *Affiliated* *
NATIONAL HOTELS

ALABAMA	
HOTEL ADMIRAL SEMMES	Mobile
HOTEL THOMAS JEFFERSON	Birmingham
DISTRICT OF COLUMBIA	
HOTEL WASHINGTON	Washington
ILLINOIS	
HOTEL FAUST	Rockford
LOUISIANA	
JUNG HOTEL	New Orleans
HOTEL DESOTO	New Orleans
MISSISSIPPI	
HOTEL LAMAR	Meridian
NEBRASKA	
HOTEL PAXTON	Omaha
NEW MEXICO	
HOTEL CLOVIS	Clovis
OKLAHOMA	
OKLAHOMA BILTMORE	Oklahoma City
HOTEL HUBER	Muskogee
HOTEL BELMONT	Okmulgee
HOTEL ALDRIDGE	Wewoka
SOUTH CAROLINA	
HOTEL WADE HAMPTON	Columbia
TEXAS	
HOTEL ALICE	Alice
HOTEL STEPHEN F. AUSTIN	Austin
HOTEL SETTLES	Big Spring
HOTEL BROWNWOOD	Brownwood
HOTEL SOUTHERN	Brownwood
HOTEL LAGUNA	Cisco
HOTEL CORTEZ	El Paso
HOTEL TEXAS	Fort Worth
HOTEL BUCCANEER	Galveston
HOTEL GALVEZ	Galveston
HOTEL JEAN LAFITTE	Galveston
CORONADO COURTS	Galveston
JACK TAR COURT	Galveston
MIRAMAR COURT	Galveston
HOTEL CAVALIER	Galveston
HOTEL PLAZA	Laredo
HOTEL LUBBOCK	Lubbock
HOTEL FALLS	Marlin
HOTEL CACTUS	San Angelo
ANGELES COURTS	San Antonio
VIRGINIA	
HOTEL MOUNTAIN LAKE	Mountain Lake

SERVING 10 STATES AND OUR NATION'S CAPITAL

Affiliated
NATIONAL HOTELS
"HOST TO THE NATION"

J-40-325

H. H. Timken, Sr., Dead

H. H. Timken, Sr., chairman of the board of The Timken Roller Bearing Company, died October 14 in his home at Canton, Ohio. The immediate cause of his death was pneumonia, which developed from chronic asthma. His illness was of short duration.

Although still active in the business, which he founded with his father and brother, in 1898, his two sons, Henry H. Timken, Jr., and W. Robert Timken, in recent years have taken an active part in the management of the company. Henry H. Timken, Jr., has been named to succeed his father, and also will continue as vice-president and general manager of the Steel and Tube Division of The Timken Roller Bearing Company.

John E. Fick, superintendent of the Steel Mill, has been added to the board.

International Cementers, Inc., Expand

International Cementers, Inc., has purchased the physical assets of Pacific Cementing Company, as of November 1, 1940, and will continue to operate in California under the same management and with the same personnel as a nucleus for expanding operations both in the United States and foreign countries.

International Cementers, Inc., has also taken over Dowell acidizing operations in California, which will be combined with the acidizing units formerly owned and operated by the Pacific Cementing Company.

The vice-president and general manager of International Cementers, Inc., R. M. Cook, has assumed the management of the new company, and R. Henquet, executive vice-president, will maintain his headquarters in the Los Angeles office of the company.

International Cementers, Inc., a Delaware Corporation, was formed by Baker Oil Tools, Inc., Byron Jackson Company, Dowell Inc., and Schlumberger Well Surveying Corporation, and is to have its corporate headquarters at Houston, Texas.

Directors of the company are: A. P. Beutel, N. R. Crawford, and C. Penhaligen, of Dowell Inc.; E. G. Leonardon, R. Henquet, and P. Charrin, of Schlumberger Well Surveying Corporation; Frank Champion of Byron Jackson Company, and T. Sutter, of Baker Oil Tools, Inc.

Officers of the new company are: E. G. Leonardon, president, R. Henquet, executive vice-president, R. M. Cook, vice-president and general manager, N. R. Crawford, vice-president, A. P. Beutel, treasurer, P. Charrin, secretary and assistant treasurer, and C. E. Whitney, auditor.

It's Costly to be a HIDDEN LEAK DODGER

Truest testimonial to RECTORSEAL is its use in a pinch . . . on tough jobs where other materials fail to stop leaks or on surface jobs where its good results are so evident. But, why confine your use of RECTORSEAL to "show places" and be content to use this or that compound for the hidden leaks which may be the most costly in the end? Why not standardize on this positive leak preventer as so many operators are doing . . . at the surface, in the well, everywhere there's a threaded or gasket connection? RECTORSEAL, in the long run, is less costly than conventional dopes!

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THE POSITIVE LEAK PREVENTER

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J. S. Alcorn and A. E. Nash Pass Away Few Days Apart

James S. Alcorn, president of the Alcorn Combustion Company, Philadelphia, Pennsylvania, died unexpectedly November 5, at Wynnewood, Pennsylvania.

Alcorn was a graduate of Central High School, and attended the University of Pennsylvania Law School. After being admitted to the Pennsylvania Bar he was for a number of years associated with the law firm of Simpson and Brown. During and following his practice of law he became interested in several companies doing business in the heating art. For the last 17 years he has been president of the Alcorn Combustion Company and had patented a number of inventions in the art of heating petroleum for the production of motor fuel. He was also a director of the Faber Engineering Company.

Arthur E. Nash, vice-president and treasurer of the Alcorn Combustion Company, died in Philadelphia on October 29.

Nash, a graduate of M.I.T., class of 1902, worked many years with the DuPont company as a research chemist, and later became vice-president of the Philadelphia Rubber Company. He resigned that position to become vice-president and treasurer of the Alcorn Combustion Company at the time of its organization in 1923. He holds in his name a considerable number of patents and was the author of several articles relating to the heating art.

T. N. St. Hill Resigns From Petroleum Rectifying

Following a six months' leave of absence from his office at the company's headquarters at Los Angeles, California, T. N. St. Hill resigned as vice-president of Petrolite Corporation in charge of the Petroleum Rectifying Company of California Division, effective October 31, 1940, to devote full time to his duties as president and general manager of Tea Garden Products Company of San Francisco, a company in which he has been a director for some time. He will, however, continue as a director of Petrolite Corporation.

St. Hill has been with Petreco 11 years, joining the organization in 1929 as vice-president of Petroleum Rectifying Company of California, and being elected president upon the retirement of D. C. Norcross in 1936.

L. G. Atkinson Promoted

L. G. Atkinson has been appointed manager of a new section of the Circuit Breaker Sales Department of the Westinghouse Electric and Manufacturing Company, it has been announced.

Atkinson was graduated from the electrical engineering school of North Carolina State College in 1933. After two years in the Westinghouse student course, he entered the engineering department of the Switchgear Division. In 1936 he went into the sales department of Switchgear and now has been made head of sales for small De-ion circuit breakers. His home is in Edgewood, Pennsylvania.

Death Takes W. A. Loomis

W. A. Loomis, inventor of the O.C.S. Automatic Weight Control, passed away October 19 at Whittier, California. Loomis had been with the O.C.S. Manufacturing Company, Coffeyville, Kansas, for the last 10 years. Although he lived in California he spent considerable time in the Mid-Continent area. His innumerable friends throughout the industry will be saddened to learn of his death.

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CHECK THESE FEATURES:

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5. All enclosed gears.
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8. Quick—accessible Unit-Type Construction.
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10. Long life, low maintenance assured and the dead-weight eliminated by super quality material.

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The above are only a few reasons why more and more people are picking Clevelands. Complete information is yours for the asking.

THE MODEL 140 PIPELINE DITCHER. Digs 18 to 30 inches wide, 5' 4" deep

THE MODEL 90
One man operated continuous travel backfiller. Handles pipe, too.

THE CLEVELAND TRENCHER COMPANY
Pioneer of the Small Trencher
20100 ST. CLAIR AVENUE **CLEVELAND, OHIO**

Trade Literature

SKF Industries, Inc., Philadelphia, Pennsylvania, manufacturers of ball and roller bearings, has released an attractive 36-page catalog entitled "SKF Spherical Roller Bearings."

●

To simplify the selection of the proper electrode for the job at hand, Air Reduction, 60 East 42nd Street, New York, New York, has announced the publication of an Electrode Selector Chart for use by arc welding operators.

Under separate guides, listed according to the metal to be welded, the chart enumerates such things as the suggested type of electrode, welding procedure, and recommended voltage and current values.

●

Reed Roller Bit Company, Houston, Texas, has published Bulletin 409-R descriptive of its line of rock bits and the new Reed SE interchangeable mud nozzle assembly to assure high efficiency in cutter tooth cleaning. Copies may be had by writing Reed Roller Bit Company, P. O. Box 2119, Houston.

●

Bulletin 48, issued by the Buckeye Traction Ditcher Company, Findlay, Ohio, gives specifications for and describes the Buckeye Model 48, Buckeye Model 12-A, and Buckeye Model 12, pipe line trenchers.

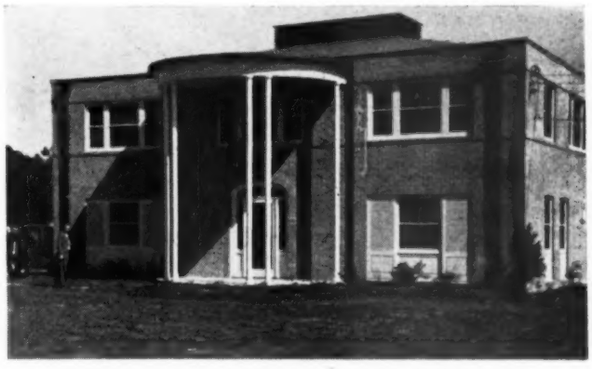
●

The Lincoln Electric Company, Cleveland, Ohio, has issued "The Lincoln Weldirectory," in which is described and illustrated the various electric-welding equipment manufactured by the company. Considerable valuable information on the selection and use of welding equipment also is given.

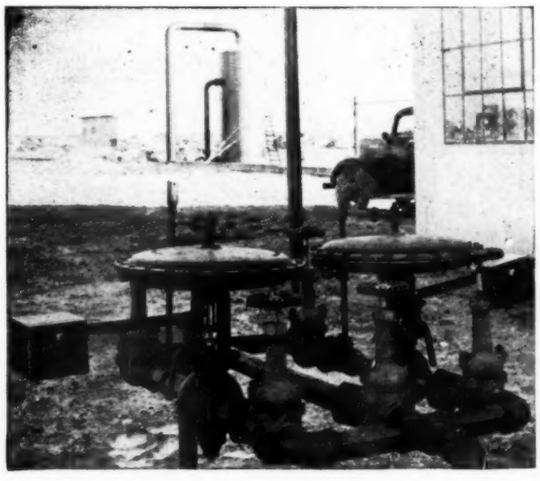
M. N. Dannenbaum Company in New Building

M. N. Dannenbaum Company recently moved into its new building at 2421 South Wayside Drive, Houston, Texas. The new quarters include a general office and six private offices, warehouse facilities, and display room. Complete stocks are being carried of Fisher Governor control equipment, Barco joints, Yarway steam traps, Thomas flexible couplings, and Peerless deep-well pumps. The company also represents numerous other accounts.

The M. N. Dannenbaum Company was founded in 1925 by M. N. Dannenbaum. Since that time other members of the organization have been added and now include: Kenneth L. Puffer, Stanley S. Williams, Ralph W. Cook, Walter B. White, Mrs. C. Andrews, and Miss M. Dannenbaum.



M. N. Dannenbaum Company's new plant at Houston



THE two C-F Low-Pressure Regulators with Automatic Cut-Off here seen are on a gas line of a Texas refinery owned by one of the great oil-producing companies. Like all C-F low-pressure Regulators, they afford protection in case of failure of gas supply. Their merits include sturdy construction, sure precision, and long life as well as easy installation and maintenance. Write for new Catalog.

The CHAPLIN-FULTON MFG. CO.

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Old enough to KNOW . . young enough to GO!

We are the oldest and largest manufacturers in the world making pumping equipment only. Yet, there's not a member of our organization who isn't young enough in ambition to go the limit in helping you lift oil for less money.

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For detailed JENSEN JACK *description and specifications, see . .* PRODUCING EQUIPMENT DIRECTORY *or* COMPOSITE CATALOG.

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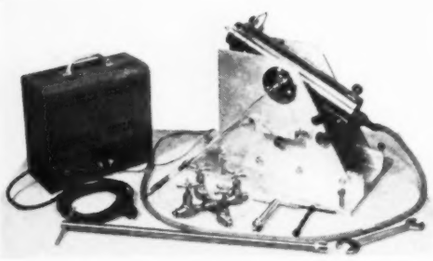
• Humble •
PRESSURE VISCOSIMETER



This equipment is manufactured and distributed exclusively by E.L.I.

The new Humble Pressure Viscosimeter, Assembly 1600-Type D, is designed to more accurately and quickly measure viscosity of subsurface samples of oil, from a small sample, and under various conditions of temperature and pressure. It can be used in conjunction with the Humble Type Subsurface Sampler and E.L.I.'s Water Bath Assembly.

Write for Bulletin

Engineering Laboratories, Inc.

Consulting Engineers and Manufacturers

TULSA, OKLAHOMA, U. S. A.

THE BEST VALVE PROVIDES *Smooth, Positive Operation*

A valve must be so constructed as to allow smooth opening and closing with the least possible effort. To guarantee this effect, the best valve positions gates directly opposite ports before wedging, and entirely *unwedges* the gates before raising them.

The best valve also cleans itself, allows ready replacement of parts through ample tolerances, and guarantees positive closure with self-releasing 30° angle wedges, and flexible-action gates that are *self-adjusting* to the two seats.

Only the parallel seat, double wedge type slide gate valve provides *all* these essential benefits. This principle, developed and perfected by Ludlow, has been universally accepted and preferred for oil, gas, and water lines since 1866. . . . Information free on request.

The LUDLOW VALVE MFG·CO·INC· SINCE 1866 TROY·N·Y·

Book Reviews

Lessons in Arc Welding. Prepared and published by The Lincoln Electric Company, Cleveland, Ohio. 136 pages. First edition, 1940. Price 50 cents postpaid in U. S. A., 75 cents elsewhere.

It is the object of these lessons to present in a concise manner certain fundamental facts pertaining to welding, a knowledge of which should enable the operator to use the welding process successfully and economically.

The text is simply and clearly written and is well supported by numerous sketches and illustrations that explain many of the points described.

* * *

A Dictionary of Metals and Their Alloys. Edited by F. J. Camm. Published by Chemical Publishing Co., Inc., New York, N. Y. 245 page, First edition, 1940. Price $3.00.

This book should be of interest to many engineers inasmuch as it is believed to be the first time information pertaining to metals and alloys has been arranged alphabetically.

Included are data about every known metal and about almost every type of commercial metallic alloy. The book is adequately cross-referenced throughout and, where necessary, historical facts have been included.

Larry O. Cox

Genial Larry O. Cox, in working regalia, stands in front of the office of the Gasoline Production Corporation's cycling plant recently completed in the Grapeland, Texas, area. He is president of the company.

The plant was constructed by the H. B. Zachry Company, of Houston, San Antonio, and Laredo, Texas, an affiliated organization. Cox is vice-president of this company. H. B. Zachry, the president, is also vice-president of the Gasoline Production Corporation.

The Houston office of the Zachry organization, in the Second National Bank Building, is devoted entirely to oilfield construction, especially of gasoline and recycling plants. The San Antonio and Laredo offices engage in general contracting work. Zachry, incidentally, is president of the Associated General Contractors of America.

Union Oil's New San Francisco Building

Union Oil Company's new San Francisco office building, situated on historic Rincon Hill at First and Harrison streets, was officially opened October 17, in commemoration of the founding of the company 50 years ago in Santa Paula, California. Ultra-modern in design, the new structure has been surfaced with buff-colored terracotta, combined with glass brick, surmounted by a tower surfaced with orange and blue glazed terracotta.

Statement of the Ownership, Management, etc., of
THE PETROLEUM ENGINEER
October 1, 1940

(This statement is published in compliance with the Act of August 24, 1912.)

Published at Dallas, Texas, monthly August through June, semi-monthly in July.

Publisher: The Petroleum Engineer Publishing Co., Dallas, Texas.

Editor: K. C. Sclater, Dallas, Texas.

Managing Editor: F. H. Love, Dallas, Texas.

Business Manager, W. T. Bryan.

Stockholders holding 1 per cent or more of total amount of stock: C. R. Barrett, W. T. Bryan, W. L. Love, Mrs. Clarence Morris, and K. C. Sclater, Dallas, Texas; J. L. Dwyer, T. J. Crowley, and Mrs. J. H. Dameron, of Tulsa, Oklahoma.

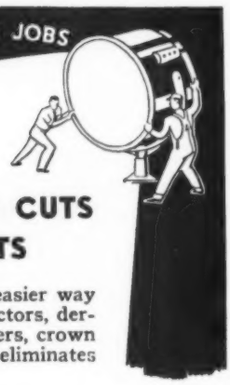
Known bondholders, mortgagees and other security holders holding 1 per cent or more of the total amount of bonds, mortgages or other securities: Johnston Printing and Advertising Co., Olmsted-Kirk Co., A. Zeese Engraving Co., Jaggars-Chiles-Stovall, Inc., Tower Corporation, F. H. Penn, Texas Power & Light Co., Dallas Clearing House Association, Dallas Gas Co., E. R. Brown, Dallas Power & Light Co., Southwestern Bell Telephone Co., F. R. Schneider, Trustee, F. V. Faulkner, A. Harris & Co., Gulf Insurance Co., Higginbotham-Bailey-Logan Co., Adolphus Hotel, The Schoellkopf Co., Industrial Dallas, Inc., Von Hoffman Press.

W. T. Bryan, Secretary-Treasurer.

Sworn to and subscribed before me this 1st day of October, 1940.

Lounette Magness, Notary Public.
(My commission expires June, 1941.)

NEW LIGHT ON YOUR CLEANING JOBS



HOW STEAM CLEANING CUTS MAINTENANCE COSTS

Would you be interested in a faster, easier way to clean such equipment as trucks, tractors, derricks, rotary tables, drawworks, spudders, crown blocks and hoists...a method that eliminates scraping and wiping operations?

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Rockford Clutches Are Tops in Power Control

A Rockford Over-Center Clutch controls the power in the pumping operation illustrated above. Rockford Industrial Clutches for internal combustion engine drives are top performers in the oil fields and in many other industries. Ruggedly built in both Over-Center and Spring-Loaded types, they give smooth, dependable, economical power transmission control under all operating conditions. The Over-Center Clutch locks in or out of engagement; the Spring-Loaded works like an automobile clutch. To get the most out of your equipment, whether buying or building, specify Rockford Clutches.

Rockford Spring-Loaded Clutch

Rockford Drilling Machine Division *Borg-Warner*
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With this Rugged New RIDGID Threader

You're rid of the bother of changing dies . . .

No. 65R-C. *Also threads short nipples, cuts drip threads — iron, steel, brass, copper pipe.*

HERE'S the modern die stock that saves you time and bother, gives you smoother threads and years of stand-up-and-take-it service. For this self-contained RIDGID No. 65R threads 1" to 2" pipe with 1 set of chaser dies — shifts quickly to each size — no extra dies to lug around *or lose.* Your choice of 2 mistake-proof work-holders, instant setting to pipe size, *no bushings needed.* And durable? . . it's all-steel malleable-alloy with drop-forged hardened tool-steel cam plates. • Compared with usual tools, you'll *enjoy* this unusual RIDGID No. 65R. Try it at your Supply Store — buy it next for surprisingly faster better threading.

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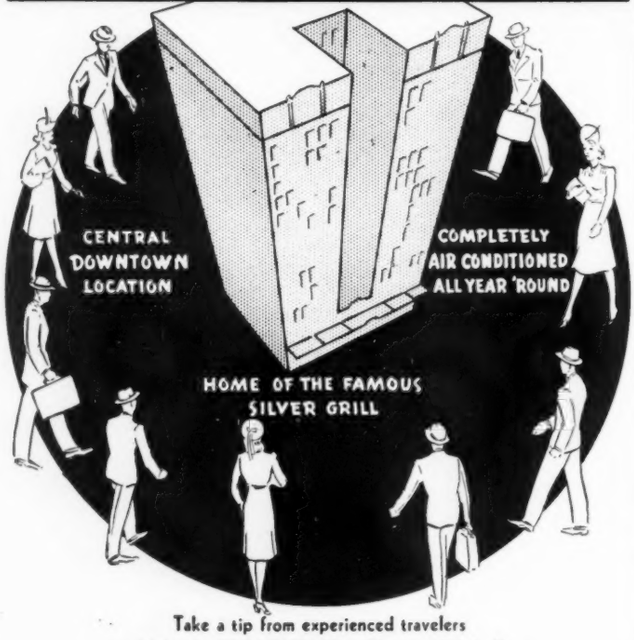

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TEXAS STATE HOTEL
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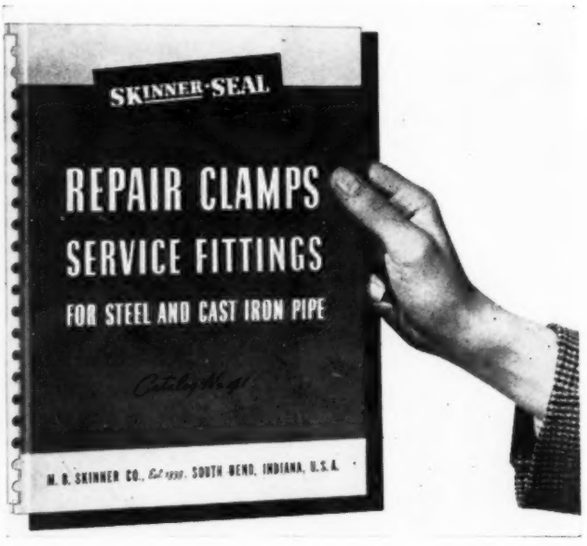
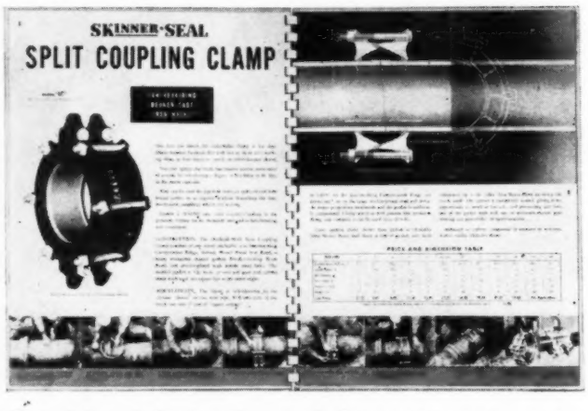
New Skinner Catalog



New Skinner Catalog No. 41



Typical spread showing closeup of clamp, cutaway view, series of installation pictures, price and dimension table, and other information

Oil men will be interested in the new and larger Skinner Catalog No. 41, just released. According to the M. B. Skinner Company, South Bend, Indiana, this catalog represents an entirely new venture in the field—being virtually a 40-page manual on repair clamps, service fittings, drilling methods, and equipment.

Larger in size (8½ in. by 11 in.), and profusely illustrated, it contains a world of useful information, complete dimensions, installation instructions, and original data that is said never to have before been published.

Attractive plastic binding makes it lie flat when opened. New Skinner-Seal items not previously cataloged include non-shift service saddle, bull-neck street tee, forged welding tee, welding tube, and various drilling devices, cutters and adapters. A series of valuable tables show the ten most widely used service methods, with data on equipment recommended for various sizes of tees, saddle outlets, pipe nipples and tubes.

Copies may be obtained by writing (on business stationery) to M. B. Skinner Company, South Bend, Indiana.

MEETINGS

American Institute of Chemical Engineers—December 2, 3, 4, 5, and 6, New Orleans, Louisiana.

California Natural Gasoline Association, Monthly Meeting—December 5, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

National Asphalt Conference—December 9, 10, 11, 12, 13, and 14, Dallas, Texas.

Petroleum Electric Power Association — December 12 and 13, Heidelberg Hotel, Baton Rouge, Louisiana.

Society of Automotive Engineers, Annual Meeting and Engineering Display—January 6, 7, 8, 9, and 10, 1941, Book-Cadillac Hotel, Detroit, Michigan.

Liquefied Petroleum Gas Association, Eastern Section, Regional Meeting—January 16 and 17, New York City.

North Texas Oil and Gas Association—February 22, 1941, Wichita Falls, Texas.

Liquefied Petroleum Gas Association, Annual Convention—February 24 and 25, Chicago, Illinois.

American Petroleum Institute, Southwestern District Division of Production—February 27 and 28, 1941, Washington-Youree Hotel, Shreveport, Louisiana.

American Society for Testing Materials—March 3, 4, 5, 6, and 7, Hotel Mayflower, Washington, D. C.

American Petroleum Institute, Division of Production, Spring Meeting, Pacific Coast District — March 11, 1941, Biltmore Hotel, Los Angeles, California.

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 11, 12, and 13, 1941, Hotel Severin, Indianapolis, Indiana.

American Association of Petroleum Geologists—April 2, 3, and 4, 1941, Rice Hotel, Houston, Texas.

American Chemical Society—April 7, 8, 9, 10, and 11, St. Louis, Missouri.

Southwestern Gas Measurement Short Course—April 15, 16, and 17, University of Oklahoma, Norman, Oklahoma.

American Petroleum Institute, Eastern District, Division of Production—April 17 and 18, 1941, William Penn Hotel, Pittsburgh, Pennsylvania.

Petroleum Industry Electrical Association—April 23, 24, and 25, 1941, Tulsa, Oklahoma.

Natural Gasoline Association of America, Annual Meeting—April 23, 24, and 25, 1941, Baker Hotel, Dallas, Texas.

National Petroleum Association—April 24 and 25, 1941, Semi-annual Meeting, Hotel Cleveland, Cleveland, Ohio.

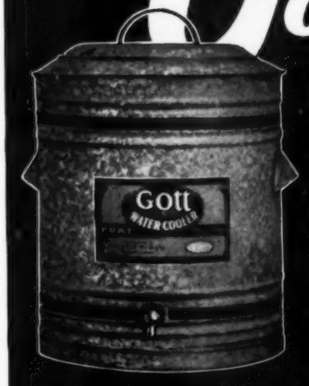
American Society for Testing Materials—June 23, 24, 25, 26, and 27, 1941, 44th Annual Meeting, Palmer House, Chicago, Illinois.

Wyatt Completes Expansion Program

Wyatt Metal and Boiler Works has recently completed an expansion program in Houston, Texas, to meet requirements for increased production. This program of expansion includes a 50 percent enlargement of the Houston office building, a new building for the accommodation of inspectors and storage of records, a new fabricating plant for light work, the installation of a new five-ton crane, and a new storage yard equipped with a locomotive crane. Production thus far in 1940 in the Wyatt plants has far exceeded that of any previous period in the company's history of more than a quarter century, officials state.

Gotkool

WATER CANS & COOLERS



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(In Pump)
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Write for Descriptive Folder and Price List

See Pages 1672-73 COMPOSITE CATALOG

PATENTED NO. 1370340 NO. 1523004 NO. 1787390 NO. 1862838 NO. 1946828 NO. 2075687

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